OIL ENGINES

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ION.

THEIR SELECTION, ERECTION & CORRECTION.

BY

W. A. TOOKEY,

Author of "GAS ENGINES: Their Advantages and Application."
"GAS PRODUCERS for Power Purposes."
"THE GAS ENGINE MANUAL."
Editor of "THE GAS & OIL ENGINE RECORD."

A HANDBOOK FOR THE USE OF
PURCHASERS,
ERECTORS,
AND ATTENDANTS.

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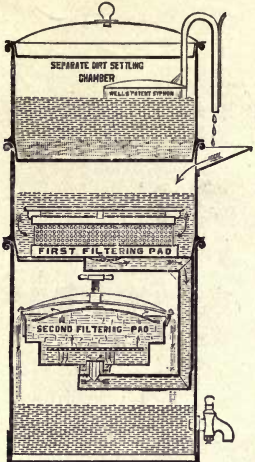

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The B.H.-P. of the Gas Engine referred to in testimonial should read 128 B.H.-P., not 12 B.H.-P.

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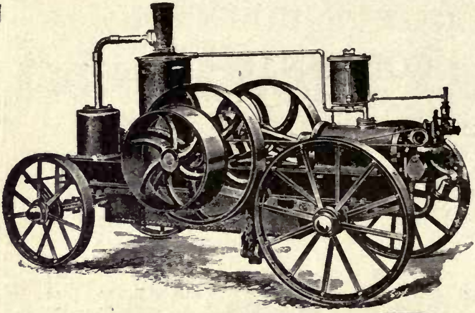

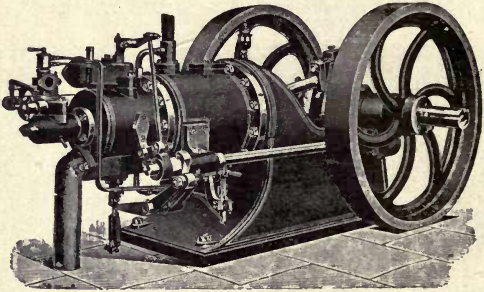

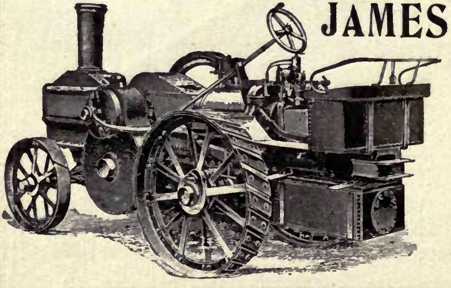

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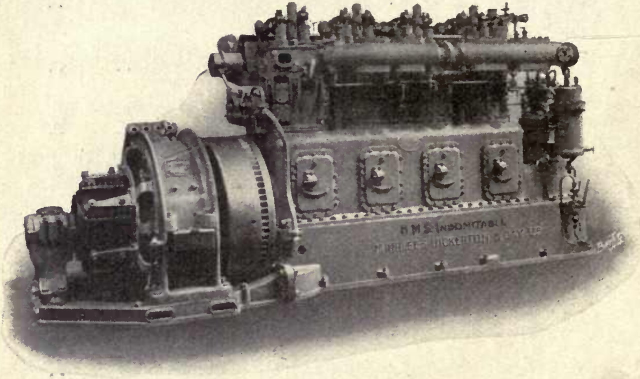


PREFACE.

The little book on "Gas Engines—Their Advantages, Action, and Application" has been so well received that a similar work dealing with Oil Engines is now placed before the public in the hope that it also will be of some service to those desiring impartial and reliable information upon the subject in non-technical language and without close study.

The introductory chapters—Part I—deal successively with Petroleum fuel, the advantages of Oil Engines, definitions of the various terms of Horse-power, and explanation of the principle of work or cycle of operations.

Part II is for the information of purchasers. It describes and compares the different methods adopted by the leading British manufacturers in the details of design, and includes a few hints to assist in making a selection.

Part III is written more for the workmen who instal and foremen and others who superintend.

Part IV is for the attendant. It contains a few words about

starting, probable failures and defects and their remedies, and some hints that may prove useful.

An appendix is added whereby the different designs of the leading manufacturers can be easily compared, and it is hoped that the descriptions there given—in each case the brief notice has been approved by the makers themselves—will form a useful guide to those interested in the subject.

The author is indebted to those firms who have allowed the use of the illustrations under which their names appear, and hereby expresses his appreciation of their courtesy.

W. A. T.

1st Edition, *February*, 1904.

2nd Edition, *December*, 1904.

3rd Edition, *October*, 1906. Revised and brought up-to-date.

4th Edition, *August*, 1908. Revised and partly re-written.

PART I—INTRODUCTORY.

CHAPTER I.

PETROLEUM.

Before dealing with the subject of oil engines, a few remarks about the fuel they consume will not be out of place.

The lighting or lamp oils generally used are distilled from the crude petroleum obtained from subterranean sources, mainly in Russia and America. These two countries yield the largest amount and most of the oil consumed in Great Britain is imported therefrom. A smaller quantity is found in Roumania, Austria, and in other parts of Europe, and a further supply is derived from bituminous shale or "petroleum peat" found in Scotland.

The crude petroleum as drawn from the wells consists of a mixture of what are termed hydro-carbons, the proportion of hydrogen to carbon in its chemical composition varying from 1 in 4 to 1 in $5\frac{1}{2}$. The hydro-carbons vary in consistency from marsh gas with a specific gravity of 0·5, to solid paraffin wax with a density of 0·98. In its unrefined state it is difficult to obtain complete combustion, owing to the extremely great heat necessary to burn the heaviest constituents without much residue. Distillation is therefore resorted to in order to separate it into commercial products.

The process of "fractional" distillation consists of subjecting the crude petroleum to gradually but steadily increasing heat

and condensing the products given off at different temperatures. At first the volatile oils are distilled and are known as benzine, naptha, gasolene, etc. These are light low-flash oils and are used for surgical purposes, street naptha lamps, various manufacturing processes, and in spirit engines for stationary purposes, as well as for motor-cars and launches, under the names of "petrol" and "motor spirit." Owing to the inflammable vapours given off at low temperatures special precautions are necessary in storing these light oils, and for all having a lower flash point than 73 degrees Fahrenheit (Abel's close test), regulations passed by the Board of Trade have to be adhered to as to storage and handling, etc.

Next in order of distillation, heavier oils, known as lamp or illuminating oils and kerosene, are passed over and condensed. The flash point of these ranges from 77 degrees to 122 degrees Fahrenheit. These oils can be less carefully stored and handled, there are no Government restrictions upon their use, and they form the fuel in oil engines such as this book describes.

After the lighting oils come "intermediate" oils (flash point up to 253 degrees F.); "lubricating" oils (flash point 262 degrees to 424 degrees F.); the paraffin wax and vaseline, and—lastly—very dense, pitch-like oils, which are used as liquid fuel.

American oils upon fractional distillation yield about :—

14	per cent. of	Volatile oils.
54	,,	Kerosene.
15	,,	Lubricating oils.
2	,,	Paraffin wax.
15	,,	Residuum and loss.
100		

Russian oils upon fractional distillation yield about :—

4	per cent. of	Volatile oils.
27	„	Kerosene.
44	„	Lubricating oils.
1	„	Vaseline.
14	„	Residuum or "Astatki."
10	„	Loss.
100		

Scotch shale oils upon fractional distillation yield about :—

6	per cent. of	Volatile oils.
38	„	Illuminating oils.
14·5	„	Lubricating oils.
11	„	Solid paraffin.
30·5	„	Loss.
100		

The kerosene or illuminating oils, as already mentioned, are those mostly used for power purposes in this country, and are always meant when the term "petroleum" or "oil" is made use of with regard to engines without other qualification. The various brands of this oil differ in both "flash point" and "density"—*flash point* being the temperature at which the oil commences to give off inflammable vapour, and usually determined by "close test" or by "open test": and the *density* being the specific gravity or weight as compared with an equal volume of water, which is taken as a unit, 1. The flash points of lamp oils, as before-mentioned,

range from 77 to 122 degrees F. (or 25 to 50 degrees Centigrade), and the specific gravities from ·79 to ·825 or ·85. It will be evident from these statements that the variations between the different brands of oil prevent their indiscriminate use in oil engines, and it is therefore important that an engine once adjusted to give the best results from a particular brand should be fed with that brand, especially in the absence of expert engineers. It has been found by experience that oil weighing 8¼ lbs. per gallon (or say specific gravity of ·825), with an open flash point of 76 degrees F., gives most power and is most economical. By raising or lowering the degree of compression of the mixture of oil vapour and air within the engine cylinder, good results can be obtained from different oils in the same engine.

If a particular brand of oil be cheaper or more easily procured than that usually used by the various makers in their testing shops, a 5-gallon sample of oil should be sent to the engine builders, so that the final tests can be made with it and the engine adjusted to suit.

In order to test various deliveries of oil from time to time so as to be certain that the proper brand is being supplied, the specific gravity and flash point can be readily ascertained by a careful man. To observe the specific gravity it is only necessary to heat or cool the oil to 60 degrees F. and to use a hydrometer, which can be purchased for a few shillings at any wholesale chemists' or stores. The bulb of this instrument will sink more or less into the oil, and the graduated scale upon the glass will then—at the surface of the oil—register the specific gravity. The determination of flash point is not such an easy matter, but an "open" test can be conducted in a sheltered place by pouring a few ounces of the oil into an open

vessel with a flat rim about a quarter of an inch above the level of the oil, and placing this vessel into another containing water, the temperature of which is slowly raised by means of a lamp. A thermometer must be placed in the oil, and a small wire made use of as a guide, along which to pass a small flame from time to time across the open vessel, the temperature being immediately and carefully noted the instant that the vapours given off from the surface of the oil cause a flash. One such test is not entirely reliable, and a mean reading of two or three should be taken. Tests are usually made with a "close test" apparatus, as designed by Sir Frederick Abel. This consists of a metal cylindrical vessel containing the oil to be tested, and an enclosing vessel containing water which is gradually heated by a lamp. The oil vessel is provided with a closely fitting cover, in which holes are closed or shut at will by slides. In one a thermometer is placed; through another a light is introduced from time to time, as the temperature increases; and a third permits of observation of the flash. By this method all currents of air are excluded, and the readings obtained are much more reliable.

The calorific value of oil is its heating value expressed in terms of British Thermal Units per lb. of oil. American "Royal Daylight" Oil has been found by Professor Unwin to have a calorific value of about 20,198 British Thermal Units per lb.; Russian oil, "Russolene," about 19,957 British Thermal Units per lb. Only 15 to 19 per cent. of this heat can be utilised in urging forward the piston of an oil engine. The cylinder walls having to be cooled by water circulation cause about 30 per cent. of the heat to be dissipated, while a further percentage escapes by the exhaust. The mechanical efficiency of oil engines still further reduces the

amount of heat available for exterior and useful work, so that of, say, 20,000 heat units in 1 lb. of oil, only about 2,400 are ultimately available for transmitting power to other machinery. A few further remarks upon this subject will be found in the following chapter, where the relative efficiencies of Steam, Oil, and Gas Engines are compared.

CHAPTER II.

The Advantages of Oil Engines.

Oil Engines using ordinary lamp oils or kerosene for fuel have been greatly improved in recent years, and large numbers have been made and sold in Great Britain for home and export. Each Oil Engine manufacturer publishes a sheaf of testimonials, all expressing undoubted pleasure and satisfaction with the engines, when doing all kinds of work. One firm alone state that the engines already made by them represent over 100,000 horse-power.

As compared with Gas Engines, Oil Engines can claim equal economy when gas is procurable at 4s. per 1,000 cubic feet, if 1 pint of oil be consumed for every 1 brake horse power at a cost of 8d. per gallon. As a matter of fact, this consumption of 1 pint per B.H.P. per hour is an outside figure for all but the smallest Oil Engines. When under the best conditions, steady load, and at nearly full power, with intelligent attention, some Oil Engine makers claim that Gas Engines show no advantage. Preference is sometimes given to Gas Engines when the absence of smell is particularly desirable, as, although when complete combustion is

attained in Oil Engines the smell of the exhaust gases is greatly lessened, yet—apart from other considerations—it is wiser not to run the risk of annoying sensitive neighbours. Hence in towns Oil Engines are rarely installed. The questions of economy, smell, and attention are those usually of most importance when the merits of gas and oil are under consideration.

Oil Engines, as compared with Gas Engines, are equally safe, convenient, and efficient. They require rather more attention, but such attention is within the capacity of any man of ordinary intelligence.

Further points in favour of Oil Engines are: (1) That no expensive connections to gas mains are necessary upon installation, should the engine be at some distance from the existing town mains. (2) Not being affected by fluctuations in gas pressure they are not liable to consequent irregularities of running. (3) Being entirely independent of outside sources of supply, the consequences of Gas or Coal labour troubles are entirely avoided. (4) Danger from leaky gas pipes is non-existent. (5) Unless the engine is constantly at work and is of large size, the smaller amount of attention necessary and the negligible quantity of water required outweigh the advantages of any combination of Gas Engine and Producer.

As compared with Steam Engines, Oil Engines have the following advantages :—

No stoker or driver. No risk of boiler explosions.
No coal. No ashes.
No extra insurance. No fire.
No chimney. No consumption of water. No sparks.
No expensive setting. No expense, except when running.

Better thermal efficiency. Better economy.

Less fuel space required. A few minutes' notice only required before starting.

The *attention* required is but slight, and supervision is needed only from time to time to see that all is in order and that proper adjustments are made to suit variations in load.

The *economy* effected is very marked.

It is stated that :—

One pound of oil yields from 18,000 to 20,000 heat units. (Boverton Redwood.)	One pound of average coal yields about 14,000 heat units. (Royal Agricultural Society's Tests.)
The thermal efficiency of the oil engine is from about 15 to 19 per cent. (Royal Agricultural Society's Tests.)	The thermal efficiency of combined boiler and steam engine is from 3 to 10 per cent. (Sir G. Molesworth.)
1 cwt. of oil by calculation should keep an oil engine at useful work for about 124 horse power hours. (Nelson Boyd.)	1 cwt. of coal by calculation should keep a small steam engine with simple valves at useful work 15 horse power hours. (Nelson Boyd.)

In order to make a comparison as to the cost of Steam *versus* Oil Engine as regards running expenses, we will assume that each engine is called upon to give, under full load, 10 Brake H.P., and that this load is constant throughout each hour. To supply a Steam Engine of this size a vertical boiler fitted with cross tubes is usually adopted, and such boilers usually evaporate from 3 to

5 lbs. of water for every 1 lb. of good coal. A Steam Engine giving 10 Brake H.P. as its maximum load would probably be developing about 12 Indicated H.P., and for a single cylinder, simple Steam Engine with ordinary slide-valve and governor, the consumption of steam for every 1 Indicated H.P. is from 40 to 50 lbs. Therefore, 12 Indicated H.P. would require, say, 540 lbs. of steam per hour, equal to about 135 lbs. of coal, if that used for lighting and banking-up purposes be neglected. Assuming coal can be obtained for 10s. per ton, the cost of handling, unloading, and storing may swell this to, say, 12s. per ton, so that the consumption per week of 3 tons would cost 36s. for 50 hours. Adding to this a man's wages and an estimated figure for water, for lighting, for banking-up fires, and cost of removing ashes and waste, we can fairly assume that the cost would not be short of 60s. per week *at least.*

An Oil Engine doing similar work would need less than 1 pint of petroleum (paraffin or kerosene lamp oil) in one hour for every 1 Brake H.P., or say 10 pints (a maximum allowance) for 10 Brake H.P. per hour. In one week of 50 hours then, 500 pints, or 62½ gallons, would be consumed at a cost of 31/3. Add to this the value of the attendant's time, during which he is prevented from doing other work—starting and stopping and occasional cleaning—say 10 hours, or 5s. per week, and the total cost—beyond lubricating oil, waste, and sundries which are common to both types—becomes, say, 36/–, or a saving of 24/– weekly, without taking into consideration the few minutes' notice required before getting to work as compared with waiting for water to boil and steam to generate.

Another point sometimes overlooked when comparing Steam *versus* Gas or Oil Engines is that inattention or neglect on the part

of an attendant—through carelessness or sudden indisposition or what not—is of no vital importance with the latter, as at the worst they can but stop owing to lack of fuel ; but disastrous consequences follow should a steam boiler be neglected.

A careless stoker can waste more fuel by improperly feeding the furnace of a steam boiler than is ever possible with an Oil Engine —which refuses to work if too much oil is fed to it. An Oil Engine, therefore, does not lend itself to extravagant habits, though the failings of its attendant may cause it to be uneconomical.

The cost of keeping an Oil Engine in good working order varies with the amount of attention bestowed upon it. The parts requiring more frequent renewals are the lamp burners, ignition tubes, piston rings, and, on the larger sizes, timing valves. The parts that require the more frequent attention and adjustment are the valves and the bearings, especially the brasses at each end of the rod connecting the piston with the crank.

At the end of four or five years the cylinder liner will probably require re-boring, and a new piston of slightly increased size will have to be purchased from the maker. For engines up to 15 or 20 B.H.P. probably a £5 note would cover the expense.

Later on the liner will again show signs of wear, and probably will not stand re-boring a second time. A new liner entirely will therefore be required, as well as a new piston to suit it. The cost of these, for engines up to 15 or 20 B.H.P. would probably be £10 to £12, if the same cylinder casing be used. The cost can sometimes be reduced and precious time saved if the makers happen to have a cylinder casing of similar size at their works, as, in such a case, it is possible for the new liner and its casing to be already fitted together when delivered on the site. The old liner in its casing

is then removed and the new one put in its place at the expense of but little time and trouble. Failing this method, a new liner, as now supplied by most makers, can be easily fitted "on the site," but more time will be taken up—a thing to be avoided when stoppage of work means loss of money.

The life of an Oil Engine may be taken as about fifteen to twenty years, more or less, according to the work put upon it during its period of service and to the attention and care bestowed.

CHAPTER III.

The Powers of Oil Engines.

The various terms of qualification of horse power are very confusing to those unacquainted with mechanics. The total effort of the exploding gases upon the piston is, of course, the maximum power developed; and, as this is usually measured by means of an instrument called an Indicator, the term Indicated Horse-power is used to denote the total power exerted upon the piston, whether the power is obtained from steam, gas, oil, air, or fluid pressure.

A certain proportion of the total power exerted upon the piston (or Indicated H.P.) is absorbed by the friction of the moving parts of the engine, therefore the term Indicated H.P. is not in itself a reliable guide as to the power that the engine is capable of giving off to another machine, seeing that some engines have more moving parts than others, and therefore more internal friction. The

amount of power available for driving other machines is termed BRAKE (or EFFECTIVE or ACTUAL) HORSE-POWER, because the contrivance by which this power is measured includes a band, which acts as a brake to the motion of the flywheel. It will be clear that the terms "Indicated" and "Brake" H.P. are relative only. It stands to reason that the maximum ratings can only be obtained when every cycle is a power cycle and when the utmost is obtained from each explosion.

The two terms "Indicated H.P." and "Brake H.P." are sufficient to denote the power of an engine worked by steam, the output of which can be kept up hour after hour so long as the steam pressure available remains constant. In Gas and Oil Engines, however, the term Brake H.P. has to be further qualified, as, owing to the heat generated by successive explosions being imparted to the cylinder, the latter cannot be kept cold enough to extract all heat and power from the exploding gases during the "power stroke." The usual allowance made by Oil Engine makers to cover the difference between the output of the engine under brake test and the OUTPUT UNDER CONSTANT WORK is about 12½ per cent. The makers usually only state the Brake H.P. that can be obtained for short periods under expert supervision.

Some makers do not test each engine for Brake H.P., but for Indicated H.P. only, the usually trifling variation in mechanical efficiency between engines of equal size (made from the same patterns, and by the same workmen) being considered negligible. The Brake H.P. specified is, then, meant as an indication as to the probable output when at full work, and one of each batch of engines simultaneously brought through the shops is usually taken as a sample of the whole, and alone tested for Brake H.P.

At the various tests instituted by the different Agricultural Societies, in connection with their annual shows, it is usually found that, *under expert attention*, the rated powers can be greatly exceeded *for short periods.*

As a matter of fact, the powers mentioned in makers' lists specify the mean powers obtained from a number of similar engines of equal size when under test, and, while some engines are capable of developing the power easily, others want "coaxing" to give off the rated H.P.

In makers' testing shops it is not unusual to hear of "good" and "bad" sizes, these expressions meaning that while the rated "list" powers can easily be obtained in one size, careful adjustment is necessary in another to attain the catalogued output.

Briefly stated, the various terms of horse-power as used in connection with Oil Engines are as follows:—

INDICATED H.P.	is the total amount of power developed by the explosions, and varies with the number of the latter during a certain period of time.
BRAKE H.P. (ACTUAL OR EFFECTIVE)	is the maximum amount of power available for driving other machines, and varies with the Indicated H.P. and with the additional restrictions consequent upon the increased number of idle strokes.
"TEST" BRAKE H.P.	is the maximum amount of power given off from the engine flywheel under the most favourable conditions and expert attendance.

"WORKING" BRAKE H.P. is the amount of power that can fairly be reckoned upon as a maximum output under ordinary working conditions for a limited number of hours of continuous work.

NOMINAL H.P. is a term deservedly going out of use. It was formerly used to denote the size rather than output of *Steam* Engines, and was from $\frac{1}{3}$ to $\frac{1}{2}$ of the maximum power for which the engine was suitable. Having no definite value, the term was no indication whatever as to the actual power to be expected from Gas and Oil Engines, and had to be dropped, as some makers who left a fair margin of reserve power found that others were rating their engines almost up to the maximum power, thus taking advantage of those purchasers who were ignorant of this.

When erecting new machinery, the makers should be asked to state what actual or Brake H.P. their machines require at the driving pulley. The answer should state a definite amount, and not an indefinite "nominal" term. Usually machine makers are given to understating the power needed.

When deciding the size of an engine the power of each machine to be driven should be carefully reckoned, and to the total of those powers an ample allowance should be made for friction of shafting and belts, and a still further margin provided for future extensions,

Sometimes the engine in use can be "indicated," and if so a competent engineer will be able to advise as to the Indicated H.P. required under varying conditions of work. Diagrams should always be taken when only the engine, shafting, and belts are in motion. This source of friction is very often understated, the consequence being an almost complete absorption of any margin that had been estimated for other purposes.

CHAPTER IV.

How an Oil Engine Works.

The principle of working most used is the "Otto" or "Beau de Rochas" cycle. Oil is vaporised by heat in a specially designed chamber, forming a continuation of the engine cylinder, but separate from the latter. The oil vapour is mixed with air in definite proportions (carefully adjusted to give the maximum strength of explosion with the utmost economy of oil) and admitted to the engine cylinder. The mixture is afterwards compressed to a degree which has been found most effective for the particular brand of oil for which the engine is adjusted. At the highest point of compression the mixture is brought into contact with a hot tube or other ignition device, and an explosion follows, of such force that the impetus thus given to the flywheel, by means of a piston and crank properly connected, causes the engine to make two complete revolutions under all its load: the cycle of operations then causes another explosion. The action is similar to that of a cannon, the projectile being harnessed to a crank and flywheel to (1) ensure its return to the proper position for being again discharged; (2) to

keep in motion the necessary gearing for automatically loading and firing at the proper moment; and (3) to provide a means whereby its power may be transmitted to other machinery.

As above stated, most modern Oil (or Gas) Engines are constructed on the "Otto" or "four cycle" principle, as follows:—

FIRST, or "OUT" STROKE.	The mixture is admitted, as the piston is drawn forward by the rotation of the flywheel, through the inlet valve, which is held open by suitable means throughout the stroke.
SECOND, or "IN" STROKE.	The inlet valve is closed, and the charge admitted is compressed by the backward movement of the piston, the temperature rising with the pressure until the stroke is completed.

(Thus one revolution of the engine crank has been made.)

THIRD, or "OUT" STROKE.	The compressed and heated mixture is fired, causing instant explosion, with great rise in temperature and great increase in pressure. The piston is forced out, and impetus is given to the flywheel's momentum. As the piston travels forward the pressure and temperature decrease.
FOURTH, or "IN" STROKE.	The exhaust valve is opened by mechanical means just before the full completion of the third stroke, and opens communication to the atmosphere. As the piston returns into the cylinder the products of combustion are expelled through the open valve, thus clearing the way for a fresh charge.

(This completes the second revolution and the cycle of operations.)

PART II—SELECTION.

DESIGN.

There are many persons to whom Oil Engines are entirely strange, who yet have sooner or later to make a selection. It is extremely difficult for such persons to decide which of the many designs upon the market would best suit their purpose, and the order is usually given with an air of dubious decision and a sigh of relief after well-meant endeavours to escape being confused by the claims and counterclaims of the makers' eloquent representatives. Not infrequently a certain make is decided upon merely because "So-and-so has got one of ———'s, and is very pleased with it." There is little doubt, therefore, that it would be of some service to non-technical people to have the principal points of difference in design shortly detailed, as it is of the utmost importance that due weight should be given to all the circumstances of each individual case. Low first cost should not be considered until the running expenses and upkeep have been calculated. Economy in oil consumption should be set against comparative simplicity. The absence or presence of trained attendants constitutes another factor for consideration.

The principal points of difference are connected with the details of :—

(1) Oil supply.;
(2) Vaporisation;
(3) Ignition;
(4) Governing;

and the object of these notes is to state the different methods employed, and thus to provide material for comparison and selection in an impartial manner.

CHAPTER I.

Oil Supply.

Three methods are adopted to deliver the oil to the vaporiser :—

(*a*) By gravity through a measuring device.

(*b*) By the action of a pump.

(*c*) By the suction caused by movement of the engine piston.

The first method—**gravity feed**—has many advantages. Entire absence of pumps, with their occasional troubles with valves and packing; no movements to suffer wear and tear; no engine power required to actuate mechanism.

On some engines a measuring device is fitted, taking the form of a valve, which can be thrown off its seat by the pushing in of a small plunger, as in a pump. By means of a screw adjustment the movement of this plunger can be varied and the valve opened more or less, as required for the different brands of oil. (See Fig. 1.) In other engines the action of the governor operates this valve, supplying more or less oil as demanded by the engine's load—the explosions occurring every cycle. (See Fig. 2.) The oil supply can, however, be similarly measured by enlarging or contracting the orifice at the inlet valve to suit the varying brands of oil—thus dispensing with one valve.

In the absence of any controlling device, engines fed by gravity are liable to be more freely supplied when the elevated reservoir is full than when nearly empty, owing to the gradually

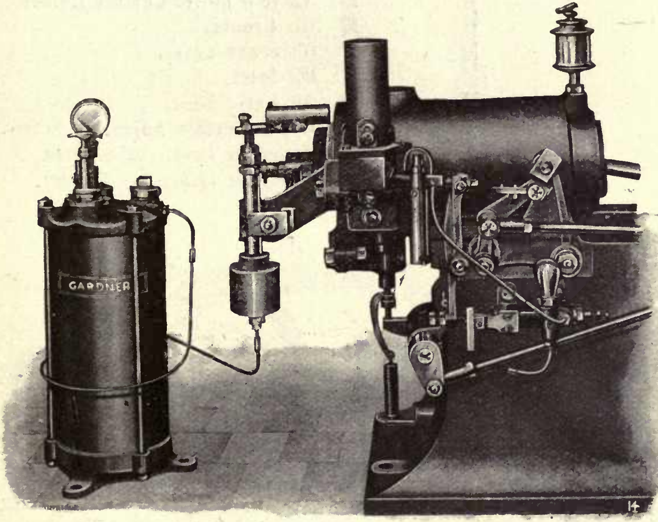
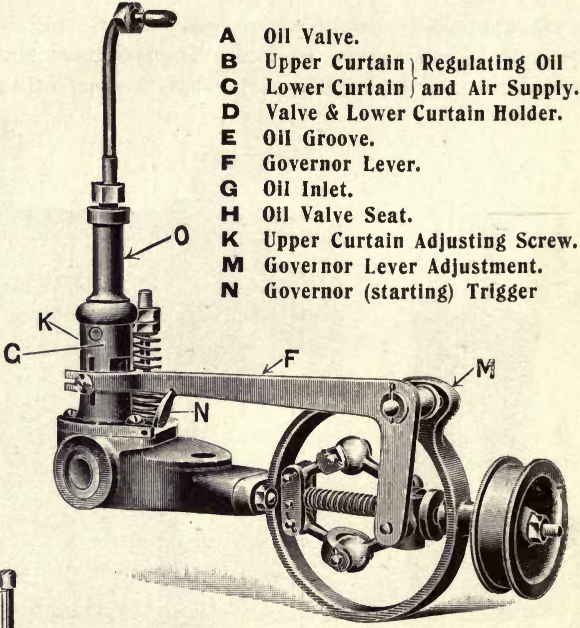


Fig. 1.

Gravity-fed vaporiser as fitted to the Gardner Oil Engine, showing measuring pump and oil inlet valve, operated by governor. The method of heating ignition tube and vaporiser, by oil burner with air pressure receiver is also illustrated.

decreasing level of the oil above the orifice of the inlet valve into the vaporiser. Engines fitted with measuring valve devices, however, are so regulated that an excess of oil

A Oil Valve.
B Upper Curtain } Regulating Oil
C Lower Curtain } and Air Supply.
D Valve & Lower Curtain Holder.
E Oil Groove.
F Governor Lever.
G Oil Inlet.
H Oil Valve Seat.
K Upper Curtain Adjusting Screw.
M Governor Lever Adjustment.
N Governor (starting) Trigger



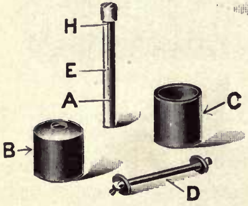


Fig. 2.
Governing Device as fitted on the Petter Oil Engine, controlling automatically the admission of oil and air in proportion to the engine's load. The oil is fed by gravity from an elevated reservoir.

is always permitted to flood the valve chamber, so that the measurer always restricts the supply to a constant quantity. The constant rate of flow that is so necessary to good working is obtained

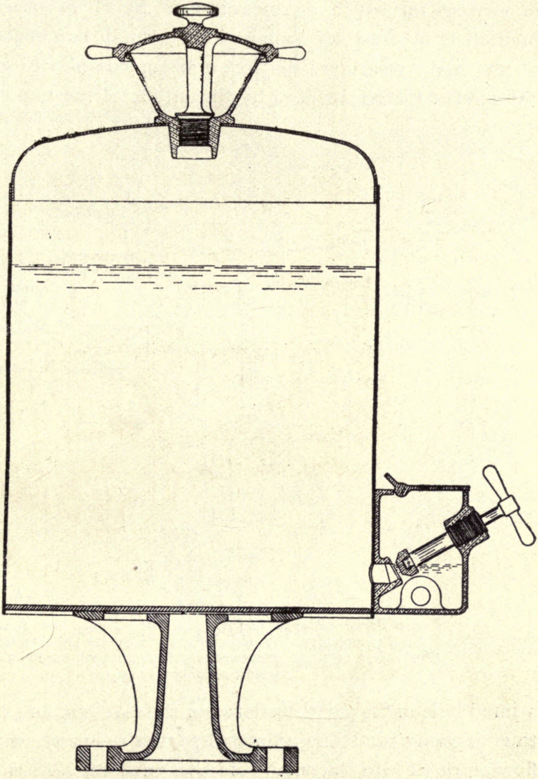
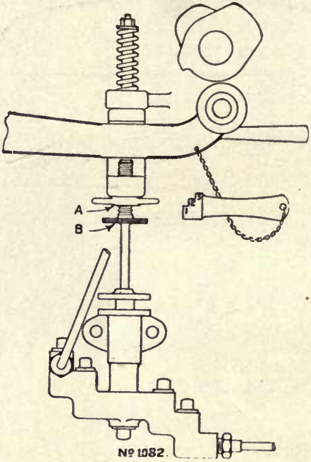


Fig. 3.

Oil Reservoir for Gravity Feed as fitted to the Tangye Oil Engine, showing method of ensuring Regular Feed.

in engines on which no measurer is fitted in other ways. One method is to draw the supply from a small box placed on the side of the main reservoir, the latter being completely air tight until the level of the oil, reduced by the supply of the vaporiser, uncovers



Gauge to set position of B in relation to A.

No. 1.—Heavy loads—most oil.

No. 2.—Medium loads—less oil.

No. 3.—Light loads—least oil.

Fig. 4.

Pump Feed. Stroke Adjustment, for varying the quantity of oil per charge. As fitted on the Hornsby Oil Engine. (For other engines, governed by intermittent explosions, these directions are reversed.)

a small hole in the partition between the side box and the main tank, thus allowing air to be admitted to the reservoir, with consequent flowing of oil into the small side box until the hole is again covered by the higher level of the oil. The action will be easily followed by studying the sketch as Fig. 3. In other engines a needle valve

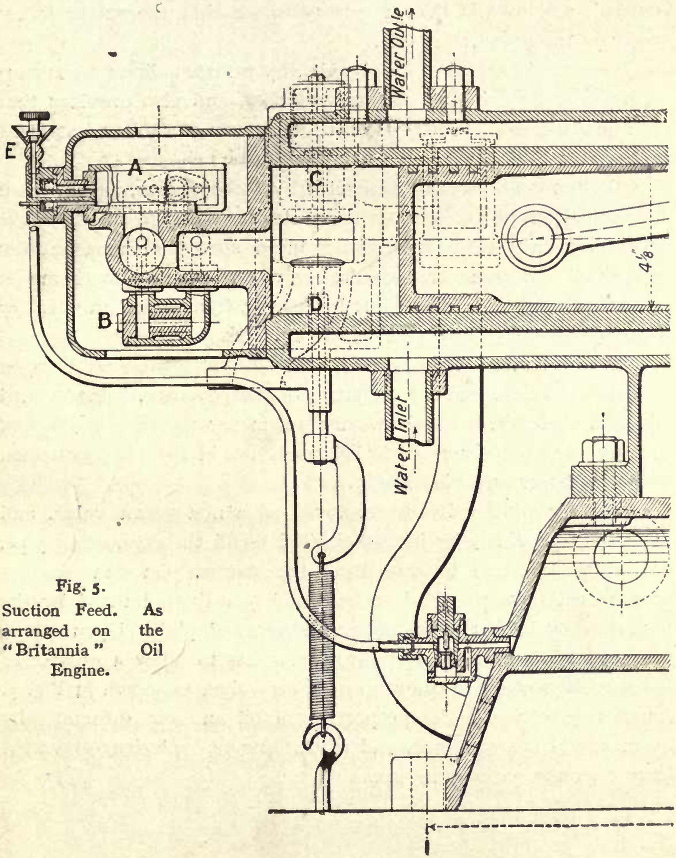


Fig. 5.
Suction Feed. As arranged on the "Britannia" Oil Engine.

is fitted, and care is then necessary to see that the action is not spoilt by the presence of grit.

The second method of supply, viz., **by pumps,** allows a constant quantity to be delivered to the vaporiser, and also provides that such quantity can be easily altered. One form of stroke adjustment is shown in Fig. 4.

Oil pumps are usually controlled by the governor, which, when the engine runs at excessive speed, causes the pump to miss a stroke or strokes until the consequent reduced speed demands another explosion. On some engines, however, the pump always makes its stroke supplying oil to a small reservoir, from which an overflow pipe conveys all excess back to the cylinder.

The third method mentioned, viz., **by suction,** depends upon the vapour valve, under the control of the governor, being opened when an explosion is required. By this means the suction effect of the engine piston draws in the oil contained in the tube connected with the reservoir. (See Fig. 5.)

A simple wing valve is employed as a non-return valve, and means are provided for introducing oil to fill the connecting pipe, to displace air, and to give the initial charge. On some engines arrangements are provided to vary the quantity admitted by the vaporiser by means of an adjustable screwed plug. Upon others the air inlet is more or less throttled so as to allow a greater or lesser suction effect to draw open an air valve, as shown in Fig. 5. Another type varies the proportion of oil and air automatically by means of the governor, and in this engine explosions of varied force continue without intermission.

CHAPTER II.

Vaporisation.

The oil, either by gravity, force pump, or suction, is fed into a chamber connected to the engine cylinder either directly or through a vapour valve (sometimes called a governor valve).

In order to convert the oil into vapour, heat must be applied to chamber, and when first starting up the use of a lamp is universal. The lamp usually adopted is described in Part IV of this book, but a brief description here will not be out of place. The common form of lamp used is one in which the oil is forced under considerable pressure through a pipe, a portion of which passes above the flame issuing from a burner. The oil is converted into vapour and burns with a strong flame of intense heat, without flare or smell. The length of time necessary for the lamp to sufficiently warm up the vaporiser ranges from five to twenty minutes, according to the type and size of the engine. (See Figs. 1, 6, and 7; pages 19, 30, and 32).

Upon sufficient heat being obtained the engine is ready to start, and it is in the method of maintaining the necessary temperature during work that the various designs can be differentiated, so far as this process only is concerned, as follows:

(*a*) By continuously burning lamp or lamps.

(*b*) By the heat derived from continuous explosions.

(*c*) By the heat derived from intermittent explosions.

In considering the various methods, it may be as well to first state the designers' claims and then to mention their competitors' objections.

a. **By continuously burning lamps.** The engines which are designed upon this method are said to deal more efficiently with ever-varying loads by keeping the vaporiser at an efficient heat, whether the explosions be few or many. The cost of the small quantity of oil used in keeping the lamp burning is saved to a large extent, if not entirely, when the engine is dealing with intermittent loads ranging from half to three-quarter full working power (as most engines do in actual work) owing to the continuous heat causing better internal combustion with less oil. Another advantage claimed is that, when necessary, the engine can be stopped and restarted at any time afterwards without trouble or delay.

One objection raised against this method is that as the heat generated by combustion raises the temperature of the vaporiser beyond that imparted to it by the lamp, the combined heat has a tendency to cause early firing when dealing with continuous heavy loads (which cause infrequent intermissions or idle strokes). This objection, however, does not apply to the engines fitted with separate lamps for tube and vaporiser, as the latter can in such cases be turned out (or, when a double lamp is fitted, either one or both of the coils can be put out of action as may be found necessary), and, moreover, the lamp under the ignition tube can usually be shifted to overcome the tendency to premature ignition. Engines having one lamp only are controlled in other ways. On some a small jet of water is introduced with each charge when heavy loads are being carried. The air pressure in the lamp reservoir is lessened in other types to obviate the consequences of overheated vaporisers.

Another objection is that the cost of the fuel supply to the lamp is of similar amount whatever the load, and therefore the lamp consumption under light loads is proportionately greater than when heavier duties are being performed, and, moreover, entirely in excess of those engines which require no lamps. There is some point in this objection, but, in defence, it is urged that while it is possible for an engine using continuous lamps to work with any load from nil to maximum, various adjustments are necessary before anything approaching the same range of load can be dealt with by engines depending only upon internal heat.

b. **By heat of continuous explosions.** The engines designed to ensure proper vaporisation of the oil by means of continuous explosions are fitted with mechanism to automatically vary the charges of oil, or both oil and air, by means of the governor, so that, under all gradations of load, some heat caused by combustion is imparted to the interior walls of the vaporiser. Under light loads less heat is thus produced than when the engine is called upon to exert more power, and it is then necessary to prevent any cooling water circulating round the passages adjacent to the vaporiser. For heavier work, when the volume of oil and air is increased and greater heat liberated upon ignition, the water in circulation can then be less restricted, and when maximum loads are being carried full circulation must be allowed. By such adjustments complete vaporisation is ensured, and it is claimed that the engines thus designed run more steadily when under less than maximum loads, than those in which explosions are entirely omitted by the action of the governor.

One objection to this method is the attention necessary when working an engine of this type for any length of time under very

light loads. Occasionally it is necessary to have recourse to the starting lamp in order to maintain sufficient heat to vaporise the oil. This objection loses weight when unvarying loads such as pumping, electric lighting through accumulators, grinding mill stones, roller flour mills, and similar work are being dealt with. A further objection is that the engine cannot be temporarily stopped, even for fifteen or twenty minutes, without re-heating the vaporiser with the starting lamp before resuming work. The adjustments necessary to ensure proper vaporisation (when greatly varying loads are being carried) usually call for rather more care on the part of the attendant of engines of this design to obtain economical results.

c. **By heat of intermittent explosions.** The engines designed to ensure proper vaporisation by intermittent explosions are provided with a valve between the cylinder and vaporiser, so that when no explosions occur, the cooling effect set up by the admission of air during the idle strokes does not affect the heat of the isolated vaporiser. The designers claim that greater economy is effected by entirely cutting out explosions, than by reducing the volume and proportions of the combustible mixture, while light loads can be efficiently dealt with by making the proper adjustments. With these engines it is unnecessary to restrict the mean effective pressure throughout the stroke in order to ensure explosions without intermission. Therefore, an engine of such a type can be made to give out more power per inch of cylinder area as compared with type *b*, with the advantage of lower first cost.

The objections to this method are the same as those mentioned in connection with the vaporisers heated by continuous explosions,

and the remarks there made equally apply to those engines now being considered.

*   *   *   *   *   *

To ensure efficient and complete vaporisation different designs again vary with regard to the admission of the oil and the air, and these variations may be classified as follows:

(*a*) Oil admitted with the full charge of air.

(*b*) Oil admitted with a small proportion of air, the larger air supply entering the cylinder through a separate valve.

(*c*) Oil injected into the vaporiser, air being admitted to the cylinder through a separate valve.

The advantages of engines designed to take in the full supply of air are stated to be that by this method the charge of vapour is more completely mixed throughout the whole volume than can be the case in those engines to which air is admitted through a valve nearer the piston. The method also allows the engine to be designed, if considered desirable, with one common valve for the inlet of both oil and air, and, moreover, this valve can be operated by the suction effect of the outgoing piston, thus rendering mechanical movement unnecessary. The omission of such mechanical movement decreases the frictional resistance of the engine and thereby more power is available for driving purposes. With those engines arranged to control the speed by propping open the exhaust valve, the compression stroke being altogether missed, a further decrease of frictional resistance is effected. (See Fig. 6.)

The disadvantages are that the large volume of cool air admitted during each charging stroke requires the vaporiser to be kept at a

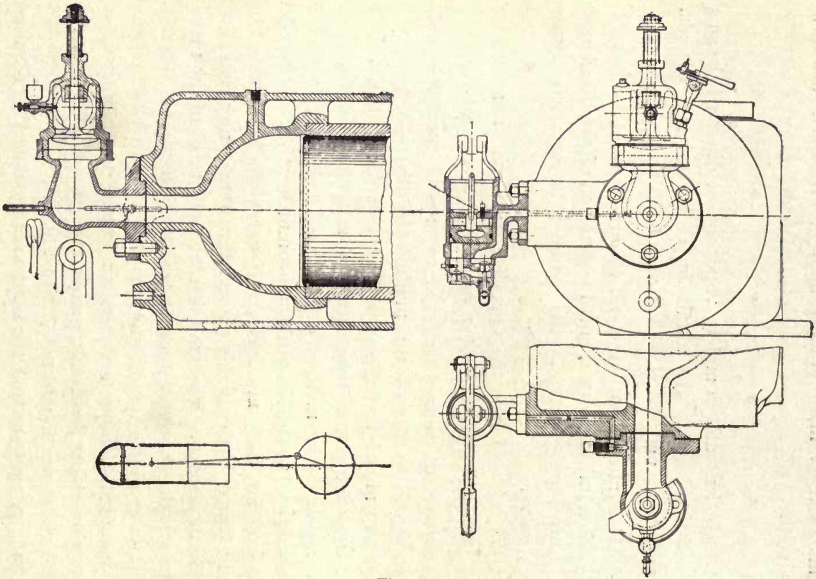


Fig. 6.

Gravity-fed Vaporiser, as fitted on the Tangye Oil Engine, showing feed-control valve, suction moved inlet valve, ignition tube and lamps. The small oil cup above inlet valve, hand pump and passages illustrate the method adopted for starting engines above 10 Brake H.P., and the diagram shows correct position for piston when the starter is applied.

greater heat than would be necessary were a small quantity only admitted with the oil, thus a slightly greater heat from the lamp is demanded. Another objection is that the mixture, as soon as the oil is vaporised, being in inflammable proportions, some brands of oil cannot be subjected to sufficiently high compression to produce entire combustion without the risk of premature ignition. An engine so constructed usually wants more frequent cleaning because of the greater amount of deposit left in the vaporiser.

Engines of the second classification, which take in a small quantity of air with the oil, are said to work more effectively, inasmuch as the mixture resulting is too rich to fire, and can be made to pass through the ignition device without danger of premature firing. The explosion in this way is delayed until the main charge of air is more and more intimately mixed by the compressing effect of the incoming piston, and such compression can be safely carried to a greater extent than in the engines of the first classification, resulting in less deposit and allowing heavier oils to be dealt with more easily.

This method, however, means more mechanism and an increase in the number of valves, which have to be kept well bedded upon their seats, and, in practical work, the engines do not show much greater efficiency than simpler types. At the Royal Highland Agricultural Society's trials in Edinburgh, July, 1899, although an engine of the second classification was slightly more efficient under full load, one, of similar size, of the first classification, was the more economical under half full load, indicating that under all but maximum loads the simpler engine could claim at least equal economy.

One of the engines designed to work with the oil injected into

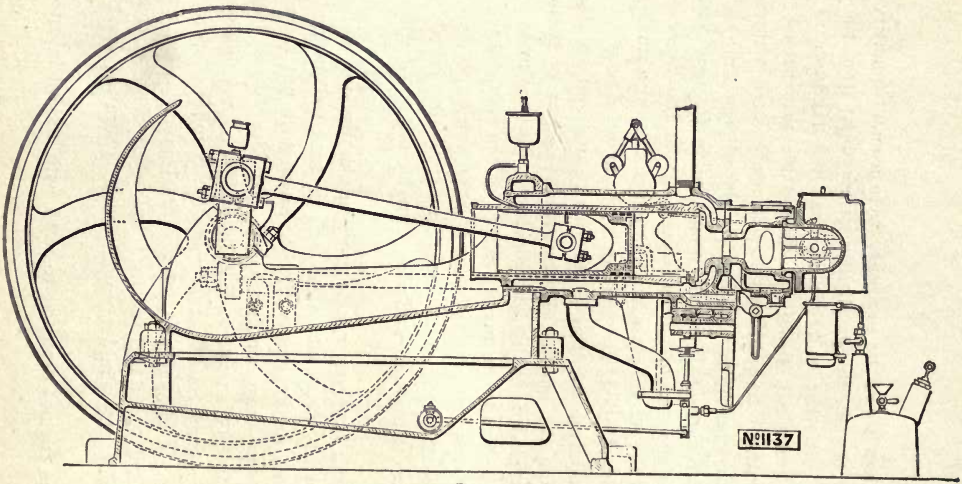


Fig. 7.

Section of Hornsby Oil Engine, showing pressure blowlamp used for starting vaporiser, and combustion chamber. The oil pump is shown connected to the vaporiser, the air charge is admitted to the cylinder direct.

a hot vaporiser while the air is being drawn direct into the cylinder, is shown in Fig. 7. The designers claim that the results achieved are fully equal to those obtained by the other methods, and the amount of compression can be increased so that any heavy oil may be dealt with economically and with a minimum of cleaning. The air is always in excess, so that complete combustion—and therefore undue deposit—is prevented. The ignition is certain, and so soon as the compression stroke forces sufficient air into the vaporiser to render the mixture inflammable, the heat of the vaporiser walls, with the temperature due to compression, is sufficient to cause the explosion.

CHAPTER III.

Ignition.

After the oil has been vaporised, mixed with the due proportion of air, and compressed by the return inward stroke of the piston, the inflammable charge is exploded by either of the following methods:—

1. By external application of heat generated by a lamp and concentrated on a certain portion of an ignition tube.
2. By internal absorption of heat generated by the continued explosions, and concentrated by a suitable device at certain portions of the combustion chamber.

3. By electric spark generated by the sudden "break" of a current of electricity flowing between two electrodes.

4. By compressing air within the cylinder until the temperature resulting burns the oil immediately upon injection, without previous vaporisation.

1. The first method is simple and requires little explanation. An ignition tube suitably shielded from air currents, is heated by a lamp which continues to burn during the whole of the time the engine is at work. In many designs the same lamp that heats the ignition tube also serves to maintain the working temperatures of the vaporiser.

2. The second method varies with the different makers, the object being to concentrate at one particular point of the vaporiser sufficient heat, obtained from the explosion of the working charges, to ensure ignition from the combined effects of the heat generated during the compression stroke, the heat absorbed on previous explosions, and the effect of the hot cylinder walls. The manner in which the speed of the engine is controlled occasionally necessitates special adjustments with this "automatic" and the "tube" ignition devices, inasmuch as the temperatures obtained when working under full loads are considerably higher than when low loads are being carried. In order that the time of firing may be controlled, two or three designs include a timing device which prevents pre-ignition. With others water injection is provided for use on the heavier loads, as by this means not only can ignition be delayed, when necessary, but improved results are obtained in respect to fuel economy. In the latter portion of this book reference is made

to special water injection devices to control ignition in this manner on the various engines mentioned.

3. Electrical ignition is not generally adopted, although for engines designed to be started up from cold by means of petrol being used as fuel for the first few minutes, the magneto is coming into use. Generally, the commercial oil engine is not fitted with electrical firing device, owing to the liability of deposit on the electrodes giving trouble—whether low-tension magneto with make-and-break sparking-plug, or high-tension magneto or battery and induction coil with jump sparking plug is used. Seeing that the ignition of the charges can be obtained automatically by otherwise waste heat, it seems to be in accord with common-sense to simplify the engine and do away with auxiliary ignition devices which involve a greater risk of breakdown.

4. The method of burning the oil upon its injection in a quantity of highly compressed air containing more than sufficient oxygen to ensure complete combustion is only applied in the engines made under the Diesel patent. This engine is designed to give a working pressure behind the piston for a much longer portion of the stroke than does the pressure generated by the explosion of a compressed charge of oil vapour and air, and thus claims to obtain greater efficiency. The air is compressed to a degree which raises its temperature greatly beyond that which would suffice to ignite the oil, so that the maximum pressure obtained by the compression of the air on the inward stroke of the piston is maintained for a greater or lesser portion of the outward "working" stroke, until the oil supply is stopped by the action of the governor.

CHAPTER IV.

GOVERNING.

All the devices for maintaining a constant speed under all conditions of load, from light to maximum, are put into operation either by the centrifugal force of rotating balls, or by the momentum imparted to a block of metal upon the end of a pivoted lever, by means of a cam or other device for imparting motion, worked by the engine and varying with its speed. The former are known as "centrifugal" and the latter as "inertia" governors.

Such governors are arranged to control the speed in three ways :—

1. By causing the exhaust valve to be held open and the oil and air charges to be omitted when not required.
2. By causing the oil charges to be omitted, air only being admitted when explosions are not required.
3. By varying the quantity of oil, or oil and air admitted, explosions, differing in intensity, recurring at each cycle.

1. The first method is applicable only to those engines whose inlet valves are opened by the suction of the outgoing piston upon the charging stroke. The action of propping open the exhaust valve spoils the vacuum that would otherwise cause the inlet valve to open, the hot spent gases returning to fill the space behind the outgoing piston, until—the speed of the engine being reduced—the governor pulls away the exhaust lever "sprag" or prop, and thus allows the normal operation of the valve motion to come

again into action. The advantages of this method are two-fold. Firstly, the heat of the exhaust gases tends to keep the temperature of the cylinder walls and the chemical constituents of the contents of the cylinder somewhat uniform, thus preventing any tendency to greatly varying intensity of explosions, as is the case when a cool charge of pure air intervenes between two "power" strokes; and, secondly, the resistance due to compression is entirely relieved, and thus the total frictional loss of the engine is lessened very materially.

The velocity of the exhaust gases, however, is so great that, unless the exhaust pipe be restricted in area at its outer orifice, thus somewhat bottling up the gases, an appreciable length of time elapses before they can be again drawn through the port to follow the piston in the out-stroke immediately following. This hesitancy would cause a momentary vacuum and a slight chattering of the inlet valve, and, consequently, very small and wasteful charges of oil and air. In larger engines of this type, where the exhaust cannot be so conveniently throttled, this tendency to chatter is prevented by a lever, actuated by the governor, which holds the inlet valve to its seat during the time the exhaust valve is kept open.

2. The second method of governing is that most frequently adopted. The governor is made to open, or fail to open, the vapour inlet valve, thus supplying or withholding the explosive ingredient to a volume of air drawn into the cylinder through a separate, mechanically moved valve, and cutting out an explosion when the speed of engine is excessive. This type of governor, when fitted to engines whose oil supply is delivered by pumps, is sometimes arranged simultaneously to hit, or to miss, the lever connected

with the pump plunger, so that, when the vapour valve is opened, oil sufficient for a following charge is delivered to the vaporiser, and while the vapour valve remains closed no further supply of oil is given. (See Fig. 1, page 19.) The action of such governing mechanism differs from the first method described in that a cold air charge is admitted to the cylinder—though isolated from vaporiser—and such charge is subjected to compression without explosion, thus resisting the flywheel's motion and increasing frictional losses. The first fires after a "cut-out" on all Oil Engines are weak as compared with the fires following an explosion, owing to the air admitted being increased in weight because of the reduced temperature of the cylinder walls, and in engines governed by the method now under consideration this weakness is accentuated.

3. Governing by varying the quantity of the explosive charge is designed for those engines which rely upon the heat generated by the combustion of continuous charges without intermission. This method allows steadier running, and the vaporiser and ignition device are kept at a more constant heat when under a medium load than when the explosions are entirely omitted. It is objected, however, that engines thus governed are not so economical under light loads as are those in which the charge is "cut out."

In the best-known type of engine on this principle the air supply is of constant volume, the charge of oil only being restricted as determined by the governor which operates upon a valve through which more or less oil is allowed to overflow and return to the reservoir by gravity. Other engines alter the volume of air as well as the amount of oil; by this means the proportion of both is unchanged.

CHAPTER V.

Hints to Buyers.

When placing an order for an engine, bear in mind the possibility of future repairs, and select a firm of standing and repute, who can send a representative with renewals at short notice upon emergencies.

The desiderata for Oil Engines are :—

1st, Good workmanship and finish.
2nd, Reliability and simplicity.
3rd, Economy and efficient working.
4th, Reasonable price.
5th, Low cost of renewals.
6th, Easy accessibility for cleaning, etc.
7th, Substantial design (not necessarily of heavy weight).

Either put the ordering of a suitable engine into the hands of some one really competent to select the type of Oil Engine most suitable for *your* work, or make up your mind to study the more renowned makes, and to thoroughly understand their principles and details. Do not take for granted all that makers' representatives say about their competitors' wares.

Do not let the question of economy decide the order without reference to other points. It may be that an engine that does not claim the utmost economy would in the end be the cheapest to run, having regard to its probable greater simplicity and freedom from slight derangements, as well as the smaller amount of power prob-

ably required to drive its own mechanism. This on light loads is of great importance.

Remember that an Oil Engine when overloaded will give off less power than it is capable of doing under proper conditions. The effect of overload is to diminish speed, which restricts the number of possible explosions. If an engine be designed to run at 200 revolutions per minute, 100 fires may be made when fully loaded; but if the overload reduces the speed to 190, the maximum number of explosions can only be 95. To run an Oil Engine always at maximum load is unwise. Therefore, an engine which gives a low figure for consumption under half-load and when running light is to be preferred.

Do not hazard a guess at the power you *think* will do your work. If possible, let a competent person take diagrams from your existing engine to find out what Indicated H.P. (Horse-power) it is developing when under full load, and base your estimate of power upon that. Failing this, ask the different makers of your machines to state in writing the Brake H.P. each machine requires at its driving pulley to give full output. Add to the total an ample allowance for friction of shafting, etc., and a margin for future extensions, and then ask the Oil Engine makers to quote for an engine in the form suggested at the end of these hints.

Do not use the term "Nominal" H.P.—it has no definite meaning. Always qualify the term H.P. as "Brake" or "Indicated." (See page 14.)

Do not be misled by the term "Brake H.P." It should be further qualified as "Test Brake H.P." or "Maximum Working Brake H.P." There is usually 12 or 15 per cent. difference between these two terms.

Do not be misled by the powers printed in makers' catalogues. They are usually maximum powers, and quoted as such. You must not expect to obtain the same result in daily work as is obtained by experts under test conditions. It is sometimes possible to obtain more power from Russian oils with high compression than with American oils requiring less compression. (In a similar way, it is sometimes possible to obtain a lower consumption with some brands of Russian oil than with American oil when giving similar powers.) It is sometimes necessary in order to allow the engines to give off the full powers named in the lists, on continuous work for many hours, that the storage capacity of water for circulation be increased. If the engine is required to work at any considerable height above sea level, remember that less power will then be given out. The decrease is about 3 per cent. for every 1,000 ft. altitude.

Do not be misled by statements of oil consumption. To properly compare different engines in this respect the suggested form of enquiry given below should be used.

An enquiry worded as follows should be used to obtain information from each maker upon identical terms, and thus to permit of a just comparison :—

"Please quote me for an Oil Engine capable of developing ——— Brake horse-power throughout a continued run of ——— hours, when '————' brand of oil is used. (For any other than well-known brands state here the flash point and specific gravity of the oil.) The engine will be used for driving ———— machinery.

"With your estimate kindly send a statement of the amount of such oil consumed per Brake horse-power per hour under 'full

test' load and 'half-test' load. Also the quantity when running 'light.'

"Kindly enumerate the fittings and spare parts included in your price, and also state the diameter of piston and length of stroke of the engine you quote for, as well as the speed recommended.

"The price you quote must be inclusive of free delivery to —— station, ———— Railway. If packing cases are charged for as an extra, please say allowance made upon their return to you."

PART III.—Erection.

CHAPTER I.

Oil Connections.

The various oil supply companies usually deliver the oil in casks or barrels of about 40 gallons capacity; but for large quantities in some districts the oil is delivered in bulk from tank wagons, each holding about 400 to 600 gallons. Naturally the oil is obtained at a cheaper rate when the latter method is employed. When empty the barrels have a considerable market price, varying with the demand and district, but usually three to four shillings each when delivered free at the company's depot.

Whichever method of distribution be employed, it is usually found to be more economical to elevate the oil to a storage tank, either by means of a simple pump—a somewhat lengthy operation—or by raising the barrel bodily by means of a pulley block and sling chain, and emptying its contents into the tank. The latter should be covered and shielded from the sun. The height of the tank need only be sufficient to feed by gravity the various receptacles used for the engine, and connecting pipes can be run to each reservoir, with taps, to control the supply, placed within convenient reach. This plan has much to recommend it, as not only is less oil wasted, but the smell of petroleum is not then so noticeable,

and the attendant's duty is simplified. Care should be taken to properly make every joint, and for this reason continuous copper or brass tubing is to be preferred. It is a good plan to place a simple filtering apparatus at the outlet from the main supply tank, so as to prevent the passage of grit and dirt which otherwise might cause trouble in the lamps, small passages, or valve seats. To show the amount of oil in the tank, a simple "float" and indicator is all that is necessary. The makers supply the necessary connecting pipes between the engine reservoir and the inlet to vaporiser, and, as the method adopted varies, no general instructions can well be given, except that care must be taken to make good joints, and that no air be allowed to settle in any portion of the connections. All ground joint faces should be brought metal to metal, and no material such as asbestos or hemp should be used between the faces. All joint faces should be carefully protected from damage when apart, and properly cleaned and freed from dirt or grit before being put together. No "weeping" must be permitted.

CHAPTER II.

Air Supply.

Some of the Oil Engine builders use the base casting of the smaller engines as an air reservoir from which the supply is drawn through a short length of pipe fitted to the inlet to the air valve box. If, however, the engine is to work in an atmosphere containing solid matter in suspension, it is preferable to draw the supply

from outside the building altogether, increasing the pipe's internal diameter if more than 15 or 20 ft. long.

Other makers supply a cast-iron box, sometimes fitted with a screen of cocoanut matting or similar material to lessen the noise of the air suction, and for all engines over 30 B.H.P. in size the use of a separate air chamber is universal. The inlet to the chamber should be as free as possible, and the chamber itself of ample size, to suit the volume required by the engine. It should be fitted as close to the engine cylinder as is found convenient, with no cocks or throttling connections throughout its length, except when connected to its proper inlet flange on the engine cylinder, where a regulator is sometimes fitted as an essential part of the engine.

While considering the supply of air, it would perhaps be as well to mention that the engine room should be well ventilated and kept as cool as possible. Both the exhaust chamber and the water tanks should be placed outside for preference.

When the water-cooling tanks and exhaust box are fitted up inside the room, the place becomes almost unbearably hot in the course of a very few hours of work. The rise in temperature and impurity of the atmosphere naturally affect the amount of air taken in during the charging stroke of the engine, and, consequently, the mixing value is not then the same as when the engine was first put in motion.

CHAPTER III.

Exhaust Connections.

At the extremity of the exhaust pipe or at a point remote from the engine cylinder a large iron vessel is fitted to receive the sudden rush of burnt gases expelled through the exhaust passages by the returning of the piston into the cylinder. The size of this exhaust chamber should be sufficient to receive the volume discharged and to allow expansion to take place, with a consequent reduction of velocity. A pipe is taken from this box to the atmosphere as direct as possible, to avoid back pressure upon the piston, and the diameter of this pipe should be increased if more than 20 ft. in length, unless two or more silencing chambers are used in series, when an increase in diameter is not so necessary. The first length of pipe from the engine should be fitted—similarly to the other connections—with flanges to facilitate removal when necessary. The silencing box should be fitted with a draining plug to get rid of any condensation that may collect in it.

The noise from the exhaust pipe is occasioned by the velocity with which the gases are emitted from the orifice, violently disturbing the surrounding atmosphere. To lessen the noise it is necessary to reduce the velocity by allowing the gases to expand and to become cooler in the process.

In connection with engines other than those which are governed by drawing back the burnt products, the most efficient way, probably, is to cool the gases as they emerge from the exhaust valve by bringing them in contact with a small jet of water. Care should

be taken to so adjust this jet that no excess of water is admitted to be ejected with the gases from the pipe. Only sufficient should be admitted to ensure all being converted into steam, which, passing with the gases, can rarely be distinguished. When this method is adopted the exhaust chamber must be connected to a drain, so that the condensed moisture can readily be discharged, otherwise the acid liquid will in time eat through the metal.

Where water for this purpose is not to hand, a series of iron chambers are used to allow of continuous expansion. In some cases pits are built and filled with loose stones, large coke, or bricks loosely stacked—a cover, provided with a large outlet pipe, being placed over the mouth of the pit. Unless under careful supervision, these pits are rather risky. Occasionally, by some derangement, unburnt vapour finds its way into the pit, and if, as is very probable, a miss-fire should then occur, there is every likelihood of a very nasty explosion. When this method is adopted the pits are usually lined with bricks or concrete, but an iron lining is much more to be preferred, as no disintegration can occur, and harmful results—such as when the exhaust valve, by sticking open, allows fine gritty dust from brick pits to be drawn into the cylinder—are rendered impossible.

Special silencing arrangements are sometimes made by enclosing a perforated pipe inside a larger one, or by inserting baffling plates between the inlet and outlet of a chamber of otherwise ordinary shape. For larger engines the gases are sometimes led into a reservoir, somewhat like a small gasholder, placed in a tank full of water in such a way that the pressure of the expelled gases acting on the surface of the water causes the latter to be forced downwards, and to act as a cushion, receiving the force of the sudden pressure

and allowing a steady and continuous flow to the atmosphere through a long vertical pipe. Sometimes the exhaust pipes of two or three engines working simultaneously, but firing at different intervals, are united in one large chamber, and from thence dispersed to the atmosphere by means of a long vertical pipe. Whatever method be employed care is necessary to avoid putting back pressure on the piston, and arrangements should be made to drain away all condensation that collects in the lowest portion of the connections.

Owing to incomplete combustion at starting, or when adjustments are temporarily deranged, some amount of deposit is carried away by the exhaust gases. It is therefore necessary to arrange the silencing chambers and connections so that they can be periodically cleaned without undue trouble.

CHAPTER IV.

Water Vessel and Circulation.

Owing to the great heat given out by the exploding gases, it is necessary to provide means of keeping the cylinder cool in order to prevent any alteration in the proportion of the mixture drawn in, and to ensure a constant strength and unvarying instant of explosion. For this purpose water is passed round the engine cylinder, etc., either by means of a pump or by the circulation of water by convection. Circulating tanks are more usually provided, and water is conveniently fed to same by means of a ball cock, or, if no constant supply is to be obtained, by hand. Rain water

or water containing no lime or salts is preferable, as the liability of choking passages by deposit is then minimised.

To ensure free and quick circulation it is necessary to exercise great care in fitting up the tanks and connections. The bottom of the tanks should never be lower than the centre of the engine crank. If they can be placed on a floor above, so much the better.

The quantity of water in circulation should be sufficient to enable the engine to work throughout its longest run at no excessive heat, say from 100 to 120 degrees F. The bare hand should always be able to rest comfortably on the top of the cylinder jacket. If an insufficient amount of water is in circulation, the water is likely to approach boiling point, and sediment is then deposited in the water passages, which in time become choked, almost entirely hindering circulation. The temperature of the water at the outlet connection on the engine should not exceed 150 degrees F. It is a mistake to allow the cylinder to run too cool, as this favours increased piston friction.

The ball cock on the supply pipe should deliver the cold water to the bottom of the tank by means of an internal division or pocket. The bottom pipe connection to the underside of the engine cylinder should be provided with a cock close to the tank, and, at the lowest point of the pipe, a T-piece should be placed and a drain cock fitted. By these means the pipes and engine passages may be emptied should frost be anticipated.

Care must be taken that no air can lodge in any part of the system of water pipes.

The return pipe should be taken vertically from the top connection on engine cylinder, and it must be given an upward tendency

throughout its length. No "dips" or "levels" must occur, or the circulation will most probably be slackened, if not entirely impeded. All bends should be opened to more than right angles and have an easy curve. The return pipe should enter the tank within three or four inches of the top rim and fully one inch or more below the bottom of the overflow orifice. In case of hand-filled tanks three or more inches of cover will be more satisfactory and safe. The overflow is usually carried to the nearest drain by an open pipe.

In case the engine should be found to get too warm, the ball valve should be propped open and a constant supply run in. Another tank will usually overcome any trouble in this respect if lack of water storage is the cause of the overheating. In a good many instances a very great improvement has been effected by taking a second return water connection from the combustion end of the cylinder to the circulating tank. Occasionally, where the question of water economy is not of prime importance, a small quantity of cold water from the main is passed round the cylinder end, through duplicate connections, and run to waste, keeping the ordinary tank circulation going in the usual way at one and the same time. If a pond, canal, or river is at hand a small pump can be used to circulate the water round the cylinder, a valve being provided to control the rate of flow.

It is necessary that during the hours of work the amount of water in circulation should be regulated according to the loads upon the engine, so that both cylinder and vaporiser can be kept at a fairly uniform heat, whether the work be heavy or light. Some makers provide for circulation of water round the vaporiser (in addition to the cylinder) for use on heavy loads only.

CHAPTER V.

Oil Engine Foundations.

Oil Engine makers provide a drawing showing, in plan and elevation, a room of suitable size to enclose the engine and its accessories, with suggested positions for the various fittings. These plans are usually drawn out with great attention to details ; and a careful study, and comparison with the instruction card also provided, is well repaid.

The foundation shown is usually a block of concrete from 10 to 12 inches longer and wider than the base casting of the engine, and from 2 to 4 feet or more in depth, according to the size of engine and the nature of the ground.

A good foundation resting on a solid bottom is very essential, and care should be taken that this is obtained, even if it means considerable expense. Upon marshy land and on gravel foreshores it is necessary to sink piles to enclose a suitable area, and a thick crust of concrete, between cross timbers, should connect the engine foundations and the piles, so as to bind all in one mass.

The concrete should be a mixture of one part of cement to four or five of sand and fine gravel, with a finishing, of, say, equal parts at the surface.

When ready to prepare the foundation the builders should mark out roughly the position, and excavate till a sufficient depth is obtained and a good bottom on solid ground secured. A couple of planks should then be put across the hole, and upon them the wooden template of the engine base—which is usually lent by the

makers for the purpose—is placed. This template must then be squared to the exact position, and the bolts and plates hung from it by means of the nuts, care being taken to leave sufficient length above the top of the template to ensure that the bolts will pass through the holes in the engine casting and will allow the nut in its final position to be screwed well home. Round the bolts should be placed 3-inch drain pipes—for the purpose of allowing free movement of the bolts until the engine has been erected, squared, and levelled. Instead of the drain pipes, wooden boxes are sometimes roughly put together to answer the same purpose. (Such boxes should be made wider at the top than at the bottom, so as to permit of easy withdrawal after the foundation has set.) These holes are filled up with rich cement and sand after the engine has been squared up and levelled, for which purpose a small " chase " should be left in the concrete bed round each bolt hole, to allow the semi-liquid " grout " to run under the engine base.

With brick foundations a good cement mortar must be used as a bond.

If neither brick nor concrete foundations be convenient, timbers, securely bolted and framed together, form a satisfactory bed; but the whole must be carefully keyed and all movement prevented, either by sinking the lower timbers well in the ground or by bolting through a solid flooring to a timber or iron bracing below. When placed upon flooring instead of the solid ground, vibration is sometimes set up, causing great annoyance. Every building appears to have a periodicity of vibrations peculiar to itself, and no general rule can be given to prevent this nuisance. The great thing is to place the engine in a corner between two strong walls or against the shorter end of the building; and by experiment the

particular speed which will not coincide with the vibratory periods of the building must be found. Sometimes running the engine faster than the usual speed is sufficient. Occasionally the engine base is bedded upon a thick pad of felt or upon two fibre mats (placed with the pile or faces together), with a plate of iron above and below—to distribute the weight equally over the surface. Such foundations, however, are usually springy, and allow the engine considerable movement, calling for special treatment as regards belting, etc. Isolating a block of concrete by a layer of sand at the bottom and at the sides has proved effective in many instances.

In any case the foundation of an engine should not be connected in any way with the footings of a main wall, or complaints of noise or vibration will undoubtedly follow.

CHAPTER VI.

Suitable Engine Sites.

In selecting a position for any engine, underground pipes or drains should be avoided.

If it be possible the engine should be placed so that it can drive on to the main shafting by means of a belt which, when in motion, will have its tight or driving side underneath. The top side of the belt will then sag and increase the area in contact with the pulleys. The distance between the centres of the pulleys on engine and shaft should be of reasonable length, and the belts should not be led off directly overhead, as the tendency of the belt to hang off the under face of the bottom pulley would occasion a large

amount of " slip." An open belt is much to be preferred to a crossed one, and should always be arranged for unless other circumstances prevailing absolutely preclude it. Whenever possible the belt should be led off at such an angle that the attendant is not hindered in getting at the relief lever, cams, etc., on the side shaft. When two belts are used, one on either side of the engine, they should not prevent the attendant getting at the working parts, as, in sudden emergency, much may depend upon the ease with which the oil supply valve can be reached and shut off.

An oil engine should preferably be fixed on a basement floor, but if this be impossible the advice of a competent man should be taken before deciding upon a position on an upper floor. It is not always the most convenient site that is the most suitable, as the probability of vibration, as well as the strength of support and walls, requires very special attention. Each building has its own peculiarities, and expert advice from both architect and engineer should be obtained before the final position is decided upon.

To avoid the use of fast and loose pulleys, shifting belts, and belt shifting gear, friction clutches are frequently fitted, and for heavy belts are almost indispensable. By the use of efficient clutches belting bills are greatly reduced owing to the absence of strain, otherwise set up by the lateral movement given to the belt by the shifting forks.

It is impossible to nullify the smell of the exhaust gases, as any slight derangement produces incomplete combustion. A position should therefore be selected so that the exhaust gases are not emitted close to the windows of a living room. In cases where this is likely to occur, the exhaust pipe should be carried above the eaves of the house roof.

For electric driving it is a mistake to use heavy belts, as these exaggerate the cyclic irregularity of the engine and cause fluctuation in the intensity of current. Many electrical installations are deficient in regularity of current mainly owing to unsuitable belts and belt fastenings.

CHAPTER VII.

Hints to Erectors.

Make sure of a solid bottom for the concrete or brick foundation to rest on.

Leave the foundation bolts loose in 3-inch round or square holes.

Let the bolts project a sufficient height above foundation.

Do not grout in the bolts before squaring and levelling up.

Do not use less than 1 part cement to 5 parts sand and fine gravel in mixing the concrete.

Study the makers' plan and instruction card before erecting the engine, and see that all necessary fittings have been sent.

In slinging be careful not to damage paint or bright work.

Measure up for lengths of pipes and put them on order, so that they will be to hand as soon as you have the engine on foundation.

Do not try to lift or move the flywheel without sufficient help.

Carefully clean all parts before putting together and wipe them with a clean oily rag. Take special care with bearings and piston, etc.

When placing the crank, be careful that the marked teeth on the gear wheels coincide.

Fix the positions of exhaust and air silencers and water vessels before beginning to run the connecting pipes to engine.

Make provision, by flanges or connectors, to allow of pipes being easily disconnected for examination.

Lay all exhaust and bottom water connections in trenches covered with iron grating or plates. Do not cement them in the ground.

Keep the exhaust pipe from 6 to 9 inches away from all woodwork.

Fix exhaust box so that the drain plug can be easily withdrawn when necessary.

Allow for expansion of exhaust piping when heated; if long lengths, use roller stays, and place exhaust silencer on two or three pieces of, say, 2-inch tube, to allow of slight movement.

In a long length of vertical exhaust pipe insert a small drain pipe and cock at a convenient place correctly disposed to get rid of condensed moisture.

Take all connecting pipes the most direct route, and avoid unnecessary angles, using right-angle bends where unavoidable. Use no elbows on any connections.

Carefully scrape round the interior of the pipe ends after screwing to remove all burrs.

Remove all interior scale from the pipes before screwing together. Use plenty of red lead in the joints, with spun yarn threads, to ensure gas and water tight connections. Use flanges for all pipes that require to be taken apart for cleaning.

Erect the water vessels on a stand the top of which is level with the centre of the engine cylinder.

Put water in the tanks as soon as possible, to test for leaks. Solder where necessary, but if only slightly "weeping," a little

oatmeal helps it to " take up." If rain water is used to fill the tanks much less deposit will be formed in the cylinder jacket. All valves must be open during the process of filling. See that no " air " locks occur.

Before starting see that all lubricators are full and wicks and syphons in proper order, and oil pipes and passages clear.

Get rid of all sand, plaster, and builders' material generally.

Turn the engine round by hand to see that all is free before turning oil on.

Expel all air from the oil supply pipes, and make sure that the water is free to circulate.

Run the engine at slow speed when first starting up, and carefully watch all bearings and make sure that sufficient lubricating oil is reaching them, before putting on the load.

See that the fast and loose pulleys are in line, and fix the positions so that the belt is on outside portion of the engine pulley when the loose pulley is being driven.

The size of the engine pulley as recommended by the makers should be taken as of the minimum diameter desirable to give off the full power of the engine—with the particular width of belt—when working at the normal speed. The fast and loose pulleys should not be of smaller diameter, but if—owing to limited head-room, for example—this size be impossible, a wider belt must be used to avoid any diminution of the number of square inches of belt area in contact with the pulley.

PART IV.—CORRECTION.

CHAPTER I.

NOTES ON STARTING.

Before a start can be made attention must be given to several points, and it depends upon the care with which the different details are carried out whether the process is easy or the reverse.

First of all, the heating-up **lamp** claims attention, and a brief description of the design generally adopted will help the attendant to follow the method of warming and lighting it. The lamp usually consists of a reservoir of oil, a hand pump for forcing the air, a gauge to register the air pressure, a filling plug (which also serves to relieve the pressure and thereby put out the lamp), a connecting tube to the burner, and the lamp coils, in the bottom loop of which the burner is placed. When at work the oil has to flow through the coil and over the flame issuing from the burner, thus causing the complete vaporisation of the oil and giving an intensely hot clear blue flame. In order to ensure the vaporisation of the oil when first lit the coil is previously warmed in a very simple manner. A small metal cup is provided below the burner and coil, and this cup is filled with a little asbestos string or cotton waste soaked in petroleum or spirit. A light is applied, and the heat generated by the burning oil or spirit makes the coil sufficiently hot in two or three

minutes. The heat can be tested from time to time by forcing a little oil through the coil by means of the hand air-pump. If liquid petroleum be ejected from the burner with a spluttering yellow flame, the oil supply should be immediately shut off and the coils allowed a few minutes longer to "heat up." A jet of vapour issuing from the burner will, when set fire to, burn with an unmistakable noise and give a clear blue flame ; then the lamp coils can be deemed at proper heat. The coils and burner cannot be too hot when the lamp is started.

Instead of having a reservoir and air pump to put the oil under pressure, and thus to send it through to the lamp coils, some makers make use of a small elevated supply tank, and thus obtain the requisite force by gravity only to ensure a good strong flame. Such tanks are usually placed about 7 to 10 feet from the ground, while the pressure reservoirs are usually pumped up to 20 to 40 lbs. per square inch, differing for various designs of engines. The greater the pressure the more powerful the flame, and thus when heating up the vaporiser a higher pressure would be of advantage. After the engine has been set to work, and if it is fitted with an internal ignition device, the working pressure should be much reduced, so that there can be less chance of the vaporiser getting overheated from the combined heat of the lamps and the continuous internal firing when under heavy loads.

One design of lamp—air pressure type—is shown in Fig. 7, page 32, from which can be seen the method of connection and the manner in which the heat generated is applied. A somewhat similar lamp, but with a horizontal flame, is shown in Fig. 1, page 19.

As soon as a good heat is obtained from the lamp it is placed under the ignition tube (or other device) and vaporiser for from

five to twenty minutes, according to the size of engine and design of lamp. Before the engine is ready to start, the tube must be of a good red heat.

During the time that the vaporiser and tube are being heated, the **bearings** must all be carefully lubricated, the syphon wicks adjusted, and the caps replaced to keep out the dirt and dust. The water **cooling arrangements** should be examined, so that the flow is restricted when first starting. On no account must the engine be started with no water in circulation. The **crank** must be placed at the correct position for starting, viz., the throw of the crank should be at or about its highest point on the firing stroke, all valves then being closed. If the side-shaft be not marked to denote this position, it is a good plan to rotate the engine in the reverse to ordinary direction (with the oil shut off) until the resistance of compression is felt; this also makes sure that the valves are properly seated and that the pressure of resistance is maintained as long as the flywheel is held against it. The crank should be left in the starting position while the compression **relief gear** is brought into action by the lever or movable roller especially provided for the purpose. If the engine be fitted with centrifugal governors, the "sprag" must be also put into position. The **oil pumps** must be examined and a few drops of oil made to enter the vaporiser. The oil pipes must be connected, and the valve opened, to ensure continuity of supply after the start has been made. Then, and not till then, the flywheel must be spun briskly round in the working direction.

The explosion should occur during the second revolution, but may be delayed until after the fourth if the oil has not at first been sufficiently vaporised or mixed. In case of any failure the oil

supply must be cut off and a few more revolutions made to get rid of superfluous unvaporised oil which has been pumped into the combustion chamber during the time that ignition has failed. It will often happen that while the flywheel is thus being rotated the mixture will fire, and it is therefore important that the speed of rotation be kept at such a rate that the momentum of the flywheel is sufficient to prevent any pre-ignition reversing the motion of the engine, and it is of the greatest importance that no arms or legs be used to rotate the wheel by pulling round by the spokes, as, in the event of a sudden reversal occurring from early firing, it is extremely probable that fracture of a limb will ensue. The safest place to impart motion to the flywheel (when the latter is fitted on the left-hand side of the engine when facing the crank from the cylinder or vaporiser end) is from the side of the wheel, with the back to the cylinder, and with the left foot in front of the crank-shaft, the right foot just behind it. With the palm of the left hand the wheel should be turned, by pushing against one of the spokes above the centre, in the reverse or backward direction, and as soon as the resistance of compression is felt, the palm of the right hand should be placed under the lowest spoke nearest the cylinder, and this spoke should be lifted with a right good swing over the top centre, the body following the movement with plenty of shoulder action, and as the stroke passes the outer centre the wrist should reverse the palm from a pushing to a lifting position on the same spoke, so that as soon as it has passed the lower centre and commences to rise again, another good swinging lift can be made to overcome the resistance of compression and to ensure that the force of the explosion, then due to occur, shall not reverse the flywheel's motion even if it be an "early" fire. A man who has learnt

the knack can start an engine of moderate size without difficulty, and a little time spent in assiduous practice will be well repaid to any attendant. If the engine is rather too much for one man to manage, help should be given by the second man standing behind the wheel and lifting and pushing the rim away from him. This man should not stand in front of the wheel, as if the engine suddenly reverses while he is gripping the rim he might be pulled off his feet and over the wheel before he could let go. When no starting device is fitted and difficulty is experienced in overcoming the resistance of the compression stroke, the insertion of the blade of a pocket knife between the relief cam and its roller is sometimes of great assistance.

For the larger sizes of Oil Engines a starting device is usually fitted. It generally consists of a receiver fitted with a pressure gauge and the necessary connecting pipes and valves to permit of communication with the interior of the engine. (See Fig. 8.) The valves are so arranged that a portion of the compressed air is allowed to enter the receiver at each cycle when the oil is shut off, and the communication is left open until the pressure in the receiver reaches a maximum which depends upon the working compression of the engine. Then the valves are shut off and the compressed gases stored until the next time of working, when, the ordinary routine of necessary details having had attention as enumerated for hand starting, the valves are again opened and the compressed gases in the receiver are allowed to act upon the engine piston until just before the exhaust valve opens, thus imparting more than sufficient momentum to the flywheel to keep it revolving while the working parts which provide for the continuity of explosions are brought into operation. After the ensuing run, and when the

oil is shut off, the receiver is re-charged ready for the next occasion, the speed of the engine being again brought up to normal as often as is necessary by admitting oil to the vaporiser, until the receiver is fully charged. No exhaust products should be permitted to

A.—Valve on steel receiver. B.—Valve on hand air pump pipe.
C.—Valve in connection with cylinder.

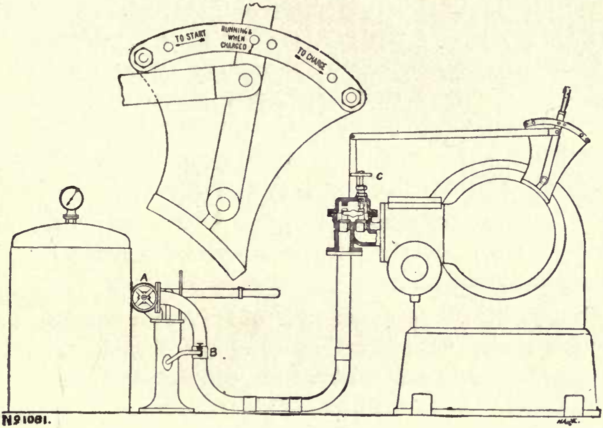


Fig. 8.

Air pressure starter as arranged on Hornsby Oil Engine, illustrating charging during the running of the engine. The small hand pump shown is used when first starting the engine.

enter the receiver, as these consist largely of steam, which, upon condensation, involve loss of pressure and also a liability of causing corrosion of valves and metal parts.

In order to start large engines for the first time after erection

the makers can in some cases supply receivers already charged, thus doing away with the necessity of either starting by hand or of providing a small engine and air compressor for the duty. The latter method is often adopted when two or three large engines have to be started, as only one receiver is then necessary, and this is independent of either of the engines.

One firm of Oil Engine builders use a simple, but effective, method of starting. A measured quantity of oil is introduced into the heated vaporiser and allowed to vaporise. After a few seconds air is pumped in by a small hand pump in sufficient quantity to form an explosive mixture with the oil vapour, which, being fired automatically by the heat of the ignition tube, gives the necessary motion to the flywheel. (See Fig. 6, page 30.)

Another firm make use of a somewhat similar device, using "petrol" or any equally volatile hydro-carbon instead of the ordinary kerosene.

When starting, a less proportion of air is required than when at work. Many engines have an adjustable throttle on the air inlet, with a handle and quadrant distinctly marked, so that the correct amount can be admitted. This throttling device is gradually thrown more or less out of action as the engine starts to work, and, when used intelligently in conjunction with the oil regulator, the correct proportion can be set and maintained to suit any load. Engines which have no adjustments provided on the air inlet require more oil at starting than when working, and are usually fitted with a controlling valve having a pointer moving over a marked quadrant. The colour of the exhaust gases will enable imperfect combustion to be detected and remedied.

Starting failures may be due to :—

1. Vaporiser and tube not sufficiently hot. The remedy is obvious. If quick starting be essential, increase the air pressure to the lamp or supplement the lamp by a small hand lamp of similar construction.
2. Too much oil or too little air. If this be the case, no explosions will occur. The oil should be entirely shut off and the flywheel rotated until the excess of oil is removed, when an explosion will sometimes occur and cause the engine to start. The air adjustment should not be less than that marked by the makers.
3. Faulty compression. The signs of this are irregular firing and lack of speed, sometimes accompanied by loud noises in the inlet and exhaust pipes. The engine should be stopped, and rotated in the reverse direction, with the oil supply cut off, until the resistance of compression is felt. If the resistance gradually becomes less and less, it proves that either the valves are not seating properly owing to the pressure of grit on the seat ; or that the valve spindles are sticky ; or that the piston rings or valve springs require renewing.
4. Too little oil. If this be the cause of failure, the explosions at first will be weak and afterwards be hardly distinguishable or will fail entirely. The supply of oil must then be increased.
5. Vaporiser or ignition device too hot. This is rarely the case, but when it happens pre-ignitions occur

which stop the engine's rotation. Water injection provides a certain means of control of ignition.

6. Wrong brand of oil. If a different brand be used other than that with which the engine was tested, difficulties will be experienced. Not only will the amount of oil per charge require to be correctly adjusted, but the amount of compression of the mixed vapour and air also.
7. Water in the cylinder. Due to condensation owing to valves being left open while at rest, or to a leaky liner joint, which must be re-made.

CHAPTER II.

Notes on Running.

As soon as the first few explosions have occurred, the air adjustment (if provided) must be gradually opened, the oil supply lessened, and the compression relief gear put out of action. In most cases it is advisable to put the engine upon some duty at once, so that the proper working heats of the vaporiser and cylinder walls are quickly attained, thus causing less deposit to be formed. It is unwise to stop the engine soon after starting, as it is not until some few minutes have passed that all internal condensation due to the cool surfaces of the cylinder and piston has been dissipated.

Sometimes after starting oil vapour arises from the air inlet to the vaporiser. This is owing to insufficient vaporisation and

late ignition, and will cease as soon as the engine has warmed to its work. Puffs of vapour from the air pipe to vaporiser can also be caused by a badly seated vapour valve, and therefore, if the escape be persistent, the valve should be cleaned and ground to its seat.

The explosions should be heard distinctly, and the escaping gases from the exhaust pipe should be almost invisible under medium and heavy loads. If the noise of explosion within the cylinder be scarcely perceptible, slightly increase the oil supply until a sharp and distinct internal sound is heard. The quantity of oil must not, however, cause a very loud noise, as this indicates waste of fuel, and makes the exhaust gases black, showing incomplete vaporisation and combustion, due to the excess of oil in proportion to air. The remedy is, not to increase the air, but to decrease the oil.

Explosions in the exhaust pipe indicate late ignition, due either to too early starting; too cool a tube; derangement of ignition device (owing to clogging up of apertures or the disintegration of the asbestos or whatever material is used); too little oil or too much air. Irregularities in the supply of oil can also be the cause of exhaust pipe explosions, so that it is advisable to see that the oil pump and its valves, etc., are in good order, and that the connecting pipes are not blocked with grit, or "air locked."

Always run the engine with as small quantity of oil as will do the work and yet give a distinct sound upon ignition, but be careful not to reduce the supply so as to cause late fires or miss fires. If the former occur it will be noticed that the charge does not fire until late in the outward stroke, and a loud report will be heard in the exhaust pipe or, if much reduced, the explosion will be missed

altogether, and the piston will pump some of the unexploded gases into the exhaust pipe, leaving the " clearance " full of weak mixture, which enriches the following charge, causes early firing of the second charge, and results in a great shock against the incoming piston.

Under heavy loads the minimum quantity of oil per explosion is needed. The reverse is the case for continuously firing engines.

Under medium loads the mean quantity of oil per explosion is needed.

Under light loads the maximum quantity of oil per explosion is needed, but for continuously firing engines less oil is wanted.

Under full loads, full water circulation should be allowed when being carried for an appreciable time—that is, when a constant and unintermittent output of power is demanded. Besides reducing the oil charge it is also necessary to decrease the heat of the lamps, either by lowering the air pressure in the lamp reservoir, or by shifting the position of the flame so as to retard the time of ignition. In engines fitted with separate lamps for tube and vaporiser, that under the vaporiser can be partially or totally put out, while that under the tube can be shifted so that the flame is projected against it at a point further away from the vaporiser. The tendency under heavy loads is to overheat the vaporiser and thus cause early firing and sometimes " cracking " and gasification of the oil rather than vaporisation, resulting in a residue being deposited, choking the vaporiser and small passages after a few hours of work. Early firing due to heavy loads is sometimes prevented by causing a very small stream of water to enter with the air ; this cools the mixture and retards the explosion.

In cases where the engine is run for long periods on heavy loads it is necessary to provide more than the normal quantity of water

for circulating purposes, and when it is inconvenient to run in cold water for this purpose (in such a manner as to cause the hottest water to be displaced and to overflow by means of the pipe provided), an additional tank should be connected. Upon consideration it will be recognised that an abnormal heat of the cylinder will cause a diminished weight of air to enter it, as, upon admission, it will at once respond to the heat and expand, filling the volume, but not with the same weight of air as when first started. Unless, therefore, the cylinder is kept cool by efficient water circulation, less oil must be given and the output of power will be decreased. As already mentioned, the use of water injection is advised when full loads are being carried.

In taking up continuous heavy loads after light or medium ones have been dealt with, it is important that the lamps and adjustments have attention as enumerated above. It is equally important to increase the oil supply and to adjust the lamps afresh when lighter loads are carried after continuous heavy loads. With constantly varying loads the adjustments can be neglected, the mean settings being probably sufficient as for medium loads. The colour of the exhaust gases for medium or light loads should be white or whitish blue.

For very light loads, and when no work at all is being done by the engine, the colour of the escaping gases is invariably white. For those types of engine designed to make continuous explosions the governor decreases the amount of oil admitted at each charge, but a further adjustment must usually be made by the attendant.

Engines which are governed by "cutting out" the oil charges require an increased supply of oil, owing to the fact that repeated non-explosive charges not only purge the cylinder from inert gases

produced by previous combustion, but also slightly cool the internal walls and cause a rather heavier charge of air to enter. In all engines the amount of heat generated by combustion is greatly diminished under light loads, and it is necessary to make use of all the available means of keeping the vaporiser and ignition device at a proper heat. The cowl or hood that usually surrounds the vaporiser should have its loose covers in place, the lamps should be burning with good flame, and the water circulation round the cylinder should be somewhat reduced and altogether shut off from the vaporiser. Engines designed to work without continuously burning lamps, sometimes need the starting lamp to be again brought into action, should the lightest loads be required for many minutes continuously.

It is of the utmost importance that the brand of oil used should be the same as that for which the engine was tested by the maker. It has been previously pointed out that different oils not only require different adjustments of oil supply and lamps, but also varying degrees of compression. It is rarely that anyone but an expert can obtain good results from a different oil without extravagance of fuel and accumulation of deposit.

It is of no less importance that the lubricating oil should be of good quality and be supplied either by the engine makers or from reputable oil refiners, who have studied the special needs of this class of engine and supply an oil that will live in high temperatures and flame, without burning and forming a gummy deposit on the piston, as the latter causes great loss of efficiency and entire failure of lubrication. Unless sufficiently lubricated with good oil the piston, under heavy loads, being without a cooling apparatus, is liable not only to be covered with gummy deposit, but to expand

to such an extent as to " seize " the cylinder walls and thus bring the engine to rest. Copious lubrication with inferior oil does not have the same effect as a sufficient amount of the proper kind. Too much oil, even of good quality, has a tendency to cause deposit. After heavy loads have been carried it is a good plan to run the engine for five minutes with no load before shutting down, and to supplement the usual feed with a hand can. A little petroleum poured into the cylinder oiling plug every now and again when stopping will prevent the piston rings from getting stuck with deposit when cold.

To stop an Oil Engine it is only necessary to cut off the oil supply, either by shutting off at the controlling valve, by propping up the governor lever so as to prevent the vapour valve and pumps from being operated, or by opening a relief valve on the pump—whichever the design may necessitate. The continuous lamps should then be turned out by relieving the air pressure in the lamp reservoir or by draining the lamp coils—as may be provided. The engine should be left with the crank on the bottom compression stroke, all valves then being closed. The outer end of the piston should not protrude beyond the mouth of the liner, otherwise it is liable to get covered with dust and grit, with possible harmful results. The engine should be carefully wiped down and the wicks of the syphon lubricators should be withdrawn from the syphon tube so as to economise oil; all oil caps should be in position. In winter weather the water-circulating cock on the bottom or cold connection should be closed and the pipes drained from a tap placed at the lowest point, in order to prevent damage by frost. After starting again, however, the water control cock should be re-opened and the oil syphon wicks replaced.

If only a temporary stoppage be necessary, the lamps under the ignition tube and vaporiser may be left burning and a start can then be easily made at any time. Engines having no continuously burning lamps, however, can be re-started without re-heating by means of the starting lamp, if not more than fifteen to twenty-one minutes elapse.

CHAPTER III.

Notes on Probable Defects and Remedies.

The most common cause of **failure to start,** or of loud explosions in the exhaust connection, is the insufficient heat of the vaporiser and ignition tube. This may be due either to trying to start too soon or the lamp flame may be out of proper trim, or too much oil may have been admitted.

Lamp troubles can be due to dirty burner coils, a blockage in the burner nipple, undue enlargement of the hole in burner nipple due to repeated probing, too little pressure, or a deficient oil supply.

The burner coils should be kept internally and externally clean. A wire brush should be used before warming the lamp at starting so as to remove any deposit on the outside of the coils, and a spare burner coil should be provided so that one can be soaked in petroleum, and any internal deposit loosened and removed while the other coil is in use.

Blockages in the burner nipples are caused by particles of grit or dust present in the oil or deposit formed in the coil. It is advisable to fill the oil reservoirs with clean oil through a fine wire gauze

strainer to minimise this trouble. The blockage can be removed by probing with a fine needle, but care should be taken to use the probe with discretion, as too frequent or careless use causes enlargement of the tiny passage, with diminution of heat and increased consumption of oil. A stock of spare nipples should be at hand for replacing those worn out, but such replacement should only be carried out when the coil is quite cold. A little petroleum applied to the screw threads is of service in making the withdrawal of old nipples a fairly easy matter. A little white lead on the thread of the new nipple helps to make a tight joint, but care must be taken that the passage is kept quite clear.

Too little pressure will cause the flame to lose its heat, and the hand pump should be used to maintain the air pressure between the limits specified by the makers upon their instruction cards. For vaporising heavy oils more heat is required, and this can be readily obtained by a little more air pressure being given to the lamp supply. For starting, a higher pressure is generally used than that advised for working, as the time taken to thoroughly warm the vaporiser, etc., is then shortened. The lamp pressure can readily be increased by means of the hand pump, or decreased by slightly withdrawing the relief (or filling) plug, thus allowing air to escape until the gauge shows the pressure required. Occasionally in the type of burner coils which is designed for the flame to pass between the two top loops, the distance between the loops diminishes or increases, causing deficient heating power. If this occurs the coils must be carefully made to assume their original position.

Slight leaks in the relief plug are sometimes difficult to trace ; an abnormal diminution in pressure should remind the attendant that this is a probable cause. Leaky joints should be at once made

good. No packing should be used, but the joint faces should be ground and brought metal-to-metal.

Should the plunger of the air pump " slip " when being worked, a little lubricating oil should be introduced to the top of the plunger through the gland encircling the pump rod, and the valve should also be examined and cleaned.

Failure of the oil supply to lamp, due to the reservoir becoming empty, can be noticed by the flame beginning to pulsate before going out. The reservoir should be filled before each long run, as it is impossible to refill the lamps while at work. Lamps fed by gravity from an elevated tank have the advantage of being readily filled at any time.

Should the engine fail to attain its proper speed, attention must be given to the *oil supply*, as either a too copious or a deficient amount may be the cause of the trouble. The *vaporiser* may not be hot enough when first starting, but this will get right with continued explosions. On the other hand, slackening of speed may be the result of the vaporiser becoming overheated, causing early firing and " bumping." The water circulation should then be increased, pressure of lamp reduced slightly if the work be heavy, or a little more oil given per charge. The *air adjustment* may also be deficient or too free, or the quantity drawn in by the piston may be laden with dust and impurities. Care should be taken that a pure supply be obtained.

The *ignition tube* may be clogged up and require scraping internally, or, if an ignition device be used, slackening of speed may indicate that renewal is necessary of the asbestos or whatever material be used for the purpose. Faulty *compression* is sometimes the cause of loss of power; occasionally it is found that the

relief gear used for starting has not been thrown out of action after the engine has been set to work. Dirty valves sometimes prevent proper seating, and need re-grinding on their seats with a little flour emery or knife polish and water. (All traces of emery should be removed before replacing the valves. Fine bath brick is recommended for these valves in preference to emery, as the cutting action being slower the seats are not damaged. It is needless to point out that coarse emery should never be used.) Bent or dirty valve spindles give similar trouble, as also weakened valve springs.

The amount of compression may probably be the cause of trouble should a different brand of oil be used to that with which the engine was tested by the maker. The remarks under paragraphs 3 and 6, on pages 65 and 66, should be read in this connection. Makers can usually supply compression plates, either to fit behind the piston or, preferably, to be put between the connecting rod large end and its brasses on the crank pin. The stroke of the piston can thus be lengthened or shortened. One firm supply similar plates to be bolted to the combustion chamber and to project within the clearance space between the cylinder and vaporiser. With two or three plates of varying thickness the correct amount of compression can be found by careful experiment. American oils usually require less compression than Russian. In converting an engine to work with the latter after many years of work with American, it will probably be found that the liner will first have to be re-bored, as the continual movement of the piston in the forward part of the liner will have worn a ridge at the place where the back piston ring reverses at the completion of each in-stroke. It is always necessary to exercise care in pushing the piston into the liner to avoid its getting jammed either in the way just mentioned

or in allowing the back ring to slip past the extreme back edge of the liner and fall out of place. When this happens, there is nothing for it but to take off the cylinder and remove the liner. Plates for bolting to the combustion chamber (instead of to the piston or connecting rod) are to be preferred, but care is necessary to ensure a good joint.

Too little compression causes slow explosions or missfires, but as these symptoms are also signs of too much oil, too little air, lack of oil, inefficient ignition (either by lack of heat or by blockage of the tube, or spent asbestos in the ignition device), these points should be looked to before any alteration is made to the amount of compression.

Too much compression tends to cause premature ignition, internal bumping, and overheating of vaporiser.

The condition of the *piston* should be noticed. Worn rings cause not only loss of compression but "blowing by" of the exploding gases with loss of power, loss of economy, and probably lack of efficient lubrication. The rings should be of soft cast-iron, not steel, as the latter metal causes undue wear of the cast-iron liner.

If the piston should be clogging and sticking, make sure that the water circulation is sufficient and that the temperature of the hot return water to the tank is not above 150 degrees F. More cold water should be brought into circulation if necessary. Tarry deposit is formed upon the piston by unsuitable lubricating oil, and a too copious supply of even good oil tends to the same deposit being formed. One remedy is to remove the gummy mass by pouring on hot water and soda while the engine is still working and lubricating it with good oil, as recommended by the makers. When-

ever the piston is liable to stick owing to the formation of this tarry substance, the piston should preferably be removed directly after the engine stops, and both cylinder and piston thoroughly cleaned. If through inadvertence the piston should be set fast, the bottom cock upon the circulating water pipe should be closed, the pipes and engine cylinder drained, and the cylinder jacket should be filled with boiling water. This causes the cylinder to expand away from the piston, which can then be readily withdrawn.

A little petroleum poured into the lubricating plug before the engine is stopped after each run keeps the rings free and allows the "spring" so necessary for proper working. When replacing the piston into the liner, turn it so that the pegs for the rings are on the top; it will then be easier. Be careful not to push it back too far, for fear that the back ring should slip beyond the inner end of the liner; and also take care that the crankshaft is not rotated while the connecting rod is lying upon it, or the chances are that it will jam the rod against the top of the liner, and probably break a piece off the portion that projects through the bed casting.

Irregularity of speed is caused either by derangement of mechanism supplying the oil to the vaporiser or to the governor being out of order. In the latter case the joints may be dirty and gummy from too plentiful lubrication, or the spindle may be bent or sticky, perhaps even the governor "sprag" for use when starting is not out of gear, causing increased speed due to no explosions being missed.

Blockages of water passages by accumulations of deposit often cause irregularity of speed after the engine has been at work for some time. The deposit must be removed by means of repeated small doses of "spirits of salts," with occasional loosening by the gentle persuasion of a sharp pointed file or similar tool.

If by some means the *liner joint* fails, water will be admitted into the cylinder from the circulating jacket, and a very small quantity is quite sufficient to prevent a start being effected. The liner must be removed, a new joint ring fitted, and all replaced. The engine must then be set going and kept at work for some time with a plank under the flywheel, so that the maximum number of explosions occur, the object being to get everything quite hot and obtain the utmost extension of the bolts. When again cool the bolts must be screwed home to the utmost extent, the cylinder being again removed, if necessary, for the purpose. If this second tightening be omitted, the joint will be liable to give way again within a short time.

Water from condensation can also get into the cylinder if the valves are left off their seats. It is always advisable to leave the crank in such a position that all valves are closed.

Bumping noises may be traced to early firing, occasioned by too much compression, too much oil, too little air, too hot a vaporiser, or it may also be due to a previous missfire (caused by insufficient heat, too little oil, or too much air).

Loud noises upon ignition point to too much oil, and the exhaust gases in that case will appear black.

Knocking noises may be due to slack bearings, slack piston, or a badly fitting flywheel key. The noise from the latter is very deceptive, but must be put right at once by driving the key well home with a sledge hammer, otherwise there is a risk of damage to the keyway on the engine shaft, making proper fitting difficult, or the wheel may become loose, or the boss of it fractured. When keys are loose, oil may frequently be detected along the keyway on the side remote from the bearing.

CHAPTER IV.

Hints to Attendants.

Read all printed instructions sent out by the makers with the engine, and try to understand all about it, its method of work, and the use of the various levers and cams, and the exact period of the "cycle" at which each acts. It is an excellent plan to make gauges of all clearance between working contacts, so as to be able to set the valves correctly after any adjustment involving the risk of derangement.

Get hints from the erectors, insurance company's inspector, or makers' representative, and ask for explanation of things you do not understand.

If you can spare the time, take note of the amount of oil consumed during each day's run, and the number of hours worked, and any particulars about the amount of work done during the day. By comparing such notes it is often possible to tell when the engine needs attention by the increased consumption of oil when doing similar amount of work.

Read the notes about starting, and the proper sequence of operations as set down on a previous page, and try to follow the same routine in the order mentioned. You will then form a habit which will make starting failures extremely rare. After any false start shut off the oil supply and rotate the flywheel. It often happens that an explosion then occurs and keeps the flywheel in motion. An explosion also may occur when engine is at rest. Be careful,

therefore, to hold the flywheel in such a way that no harm can happen through unexpected ignition.

Attend particularly to the oiling arrangements. Keep all passages clear, and make sure that the oil reaches each point that wants lubrication. See that the worsted syphons are not twisted up, so as to unduly restrict the supply. Keep all oil boxes covered up, but not so tightly that air cannot enter. Do not let any part be flooded with oil, and avoid waste. Use only good oil, and for the cylinder and piston it must be of special quality to stand excessive heat and flame, as selected and advised by the makers, or by some experienced person. After the oil has once passed the cylinder it may be filtered and used once more, but upon the bearings or other machines only. Ask your employer to buy a filter for this purpose ; it will save money. Remove the wicks after each run, as, if not, the oil will run to waste. Be careful to replace them before starting again.

Do not run the bearings with loose caps ; the brasses should be tightly screwed, metal-to-metal, so as to make a solid bush. If too much metal has been scraped away to allow of this without heating, a thin liner should be inserted between the joints and screwed hard up. Care must be taken not to adjust too tightly, or trouble will ensue. With Oil Engines especially, knocking due to loose bearings should be seen to at once, or the engine will go wrong, and possibly the brasses will need renewing rather than mere adjustment. The brasses within the piston will probably require the more frequent adjustment and the pin round which they fit will also require renewal when worn oval.

Keep all dust and grit away from the piston and bearings. During any building operation cover the engine over with a

tarpaulin or cloth. (*Dirty sacks* are sometimes used for the purpose, but cannot be recommended.)

Equally tighten all gland and cover nuts—do not screw one nut tight home before the rest have been equally screwed up, but gradually tighten all in turn until no further movement can be obtained, with moderate power according to the strength of bolt.

Keep all bolts and nuts tightly screwed up.

The ignition arrangements should be kept in good trim, and in case of renewal of tubes, mind that the fresh ones are similar to the others as regards length and internal diameter. No leakage must be permitted, nor blockage by deposit. Rotate the flywheel before replacing tube to get rid of all dust and carbon by force of compression.

Lamps require singularly little trouble if intelligent care be given. Read the remarks on page 72.

Remember that most deposit is formed during the first few fires while the engine is warming up—too much oil causing incomplete combustion makes more. An overheated vaporiser—causing burning rather than vaporising—is also the cause of carbon deposit.

When intending to dismantle the engine after a run a little petroleum applied to threads of nuts while hot will be of assistance in unscrewing. A little graphite smeared on the threads when replacing will prevent them getting "fast" during work.

Engines fitted with glass sight tubes through which the oil is passed on the way to the vaporiser should have the glasses removed before the heating-up lamps are lit; otherwise breakage will ensue, owing to the cold oil suddenly cooling the tube as soon as a start is effected. The glass tube can be replaced by brass

tube if such difficulty is experienced, and if the trouble of removing and refitting the glass tube be deemed a nuisance.

Take trouble to ensure a clean supply of oil to vaporiser and lamps. Allow no leaks in any connection. To lessen trouble arrange to empty the oil casks into an elevated tank and run connecting pipes with cocks to the different oil reservoirs, and another cock, at a convenient point, where a supply can be taken off for filling a hand oil-can or illuminating lamp reservoirs and such like.

Place a little tray under the cams and levers to collect the drips of lubricating oil and empty same occasionally.

Do not leave any oily waste lying about. It is very dangerous, being liable to ignite spontaneously.

When probing the lamp nipple, have a lighted taper at hand to relight the flame when it goes out.

Test a sample of each bulk of petroleum oil as received—the specific gravity by means of an hydrometer, which can be bought at any chemist's or stores for a few shillings; and the flash point by careful open test. (See page 4.)

Do not interfere with any of the locked nuts or settings on the engine levers, or other adjustments. No alterations should be made for the sake of experiment. Once adjustments are varied it requires a very expert Oil Engine "tester" to put things right, as he has not only to get the engine to work, but to work *economically*, as when first sent out by the makers. If ever you are at a loss to know what to do, do not interfere, but call in somebody who does know.

If the engine gives out after working satisfactorily, you may be sure that either it wants cleaning or that some of the connections or fittings are deranged—perhaps the pipes are getting choked

up. Whatever the cause, it is most unlikely to require re-adjustment of the settings, so that they should be left entirely alone. Very often Oil Engines are blamed and time is spent in taking to pieces and replacing again, when all the while the trouble is not in the engine at all. Before you touch the engine you must be sure it needs attention, and know what you are going to do, and what the result will be. Do not experiment.

Keep all your tools together, so that you can always find what you want when you require it. Hang up your spanners tidily upon the wall.

Keep your spare parts clean and available at a moment's notice ; as soon as you use a " spare," have it replaced.

Have a pair of piston-ring pliers to aid in renewing rings. They are cheap, and save many breakages when carefully used.

When you see a defect, remedy it as soon as possible ; if beyond your powers, call your employer's attention to it and have it put right. Thoroughly overhaul the engine at least once every two months, and make careful examination of its condition. Do not put off such periodical attention if all seems right, as breakdowns may occur without warning, and cause great inconvenience and annoyance, and it is very probable that signs of weakness might have been noticed and defects remedied if the periodic overhauling had been done at the proper time.

Keep the engine room tidy and clean, so that it may be inspected at any time.

Do not touch any portion of the engine while in motion ; reserve the cleaning and wiping until the engine has stopped.

Never try to tighten or loosen nuts while the engine is run-

ning ; the spanner may slip off and your own balance thereby be upset, with serious results.

When starting, do not put your foot on the flywheel, for fear of back-fires. For the same reason be careful that the compression centre is overcome by turning the wheel smartly, as, if not, the explosion may send the wheel back in the reverse direction and pull you over the top of it.

In wintry weather turn off the cock on the bottom water connection and drain the engine cylinder and pipes ; make sure that the cock is turned on again when next setting to work. A light is sometimes left burning under the cylinder, instead of draining the pipes.

Feel the external surface of the cylinder from time to time to know that it is not getting too hot. If you cannot bear the palm of your hand against it, run in cold water to the tanks.

If by neglect the water circulating passages have become blocked up or unduly restricted by deposit, take off the covers and apply a little "spirit of salts." Repeated applications and the use of a sharp pointed scraper will soon have the desired result.

When ordering any broken or worn-out part do not give it a name, as possibly that particular portion is known by an entirely different word by the makers, and confusion may arise. Make a rough sketch of the part, giving all important dimensions, and quote also the number of the engine (usually stamped upon the bed or name-plate). Merely quoting the number of engine is not always sufficient, as, in the course of years many details are altered in size and design, the changes being, in some cases, so gradual that a difficulty is experienced by the makers in knowing exactly how any particular engine is fitted. A sketch, therefore, however

rough, is often of great advantage, and the means of preventing vexatious delays through insufficient verbal description.

Allow nobody to tamper with the engine, and be chary in accepting a man at his own estimate, who boasts that he " knows all about Oil Engines."

When cleaning the engine, uncouple the big end of the connecting rod from the crank, while the latter is at its highest point. Then carefully let the throw of the crank turn to its lowest point, meanwhile holding the end of the connecting rod to prevent it from suddenly falling. Pull the piston out at once—lowering it carefully on to a block of wood placed for that purpose—and scrape the " back end." Make the rings free and see that they all fit round their pegs. Before putting back the piston take the valves out, clean and re-surface the seats by grinding with a little flour emery, slightly oil the valve spindles, and before putting in place insert a light through one of the valve seats and look through the open end of the liner to inspect the condition of the interior as regards cleanliness and wear. If the piston rings require renewing, change the back one first, as this always gets the most wear and should be a good fit. Clear all deposit from the vaporiser and passages. Use petroleum for soaking into hard lumps of residue ; your work will then be easier.

When renewing asbestos or other packing be careful to use material of similar thickness, as otherwise the working parts connected thereto may be put out of alignment.

When clearing holes take care not to enlarge them, and especially those for the supply of oil. Wash out the pumps and valve bodies with petroleum. Examine the valve seats to see whether they are defective. Re-pack leaky pump glands, but be careful to work

the plunger while screwing up to avoid " binding." On no account should oil be allowed to soak into the packing, otherwise a tight gland is impossible. Lamp cotton rubbed with dry glycerine soap is recommended as a packing.

Examine oil filters and gauze strainers from time to time, and clean when necessary.

In case of difficulty write to the makers of the engine. They will always be pleased to help you.

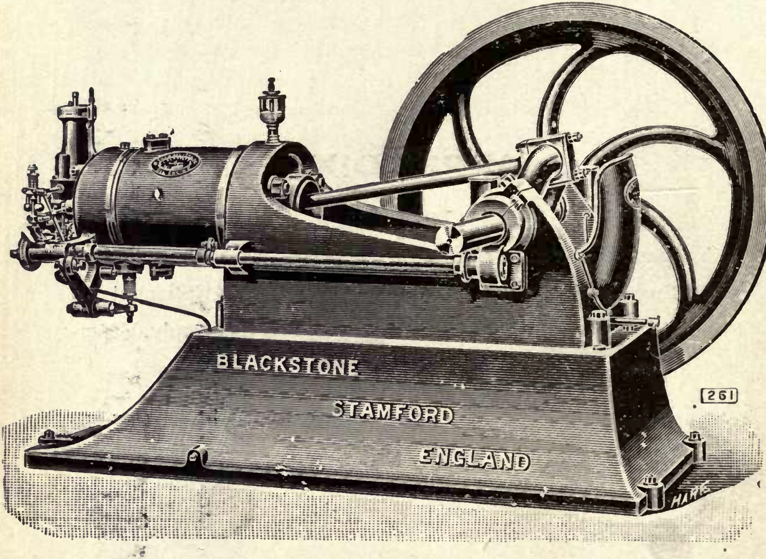
APPENDIX.

To permit of ready comparison between the various designs of Oil Engines as now made, the following brief descriptions detail the methods adopted in each case, with regard to Oil Supply, Vaporisation, Ignition, and Governing.

The illustrated notices have in each case been approved by the Manufacturers.

BLACKSTONE OIL ENGINE.

Made in 16 sizes from 1 to 60 B.H.P.



The oil reservoir is placed in the engine base. The oil supply to the vaporiser is delivered by a pump.

Governing:

The governor is of the centrifugal type, and is arranged so that at normal speed a connection is made whereby the lever operating both the inlet valve and pump plunger is put into motion. When

the speed is excessive the connection is missed, so that no movement is given to the inlet valve or to the pump plunger. Charges are, therefore, entirely omitted until the speed is again reduced.

Vaporisation :

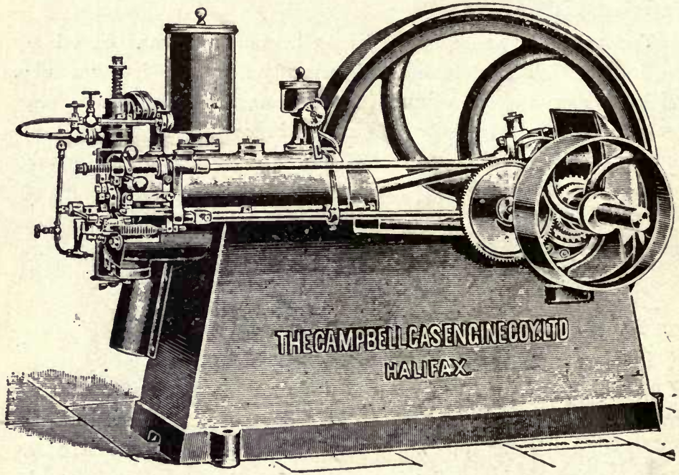
The vaporiser is kept sufficiently heated by means of a lamp continually burning, which simultaneously heats the ignition tube. The oil is delivered by a pump into an annular chamber and there converted into vapour, air is warmed in an outer annular space enclosing the vaporiser and both are admitted through the inlet valve into the cylinder. The combustible charges are entirely omitted whenever the speed of the engine rises above the normal, the governor causing the inlet valve and pump plunger to remain idle until the speed is reduced. The stroke of pump is adjustable.

Ignition :

Ignition is caused at the highest point of compression by means of a tube kept at red heat by the same lamp that heats the vaporiser. The lamp is of the usual blow lamp type, receiving its supply of oil under pressure from a separate reservoir. On the larger sizes a timing valve is provided, so that connection to the hot tube is prevented until the correct time for obtaining best results and pre-ignition avoided. On some of the latest designs the tube is replaced by an internal ignition device which retains the heat from the explosions, and renders a continuously burning lamp unnecessary.

CAMPBELL OIL ENGINE.

Made in 20 sizes, from 1½ to 100 B.H.P.



The oil reservoir is supported by the top of the engine cylinder.

The oil supply flows by gravity into the vaporiser, the quantity being adjustable by a valve which governs the rate of flow.

Governing:

The centrifugal type of governor is adopted, and is driven by means of screw gearing direct from the crankshaft. By its action a wedge is interposed during the exhaust stroke of the engine

between the exhaust lever and the rigid governor bracket, thus preventing the exhaust valve from closing whenever the speed of the engine is above the normal. The spent gases expelled by the piston on the exhaust stroke are by this means drawn back upon the succeeding out-stroke, thus spoiling the vacuum that would otherwise cause the inlet valve to let in a further charge. The engine, therefore, entirely misses explosions when above normal speed. The hot gases brought back keep the interior walls at practically constant heat even when on light loads, and this method is considered preferable to allowing fresh cool charges of air to enter during idle strokes.

Vaporisation:

The vaporiser is in direct communication with the cylinder, no valve intervening, and is kept hot by a lamp constantly burning. The oil is led into an annular chamber surrounding the inlet valve box, and small holes lead from this chamber to the conical face of the inlet valve seat. The inlet valve is held against this seat by a spring, the tension of which at every suction stroke is overcome by the suction effect of the engine piston admitting a supply of air into the vaporiser, and with it the definite quantity of oil that will flow by the force of gravity through the restricted orifices in the valve seat. This oil is swept in by the air and spread over the interior walls of the vaporiser, instantly becoming vapour, which mixes with the air and forms a combustible mixture.

Ignition:

The mixture is fired by an ignition tube which is kept hot by the same lamp that is used to heat the vaporiser. The lamp is

of an improved Vesuvius type, with a large oil chamber, which keeps the flame going for a long period of time. Provision is made to regulate the temperature of the flame, and thus irregular burning due to fluctuating loads of the engine may be controlled. Water injection is provided on all engines above 6 B.H.P.

THE CAPEL OIL ENGINE.

Governing

is by ordinary "hit and miss." A vapour valve being controlled, whereby fresh charges are admitted to the cylinder only when required to maintain the normal speed.

Vaporisation:

The vaporiser consists of an inner and outer sleeve between which the air is sucked in and warmed, meeting the paraffin entering a regulator nozzle. The air and paraffin then pass over some hot pegs, becoming thoroughly vaporised, and are led through a positively opened vapour valve from the bottom of the vaporiser. The latter is maintained at the required temperature by a lamp, the air pressure in which is automatically sustained.

Ignition:

The same lamp that heats the vaporiser keeps an ignition tube red-hot. The flame of the lamp plays across the tube and on to that part of the vaporiser that contains the aforesaid pegs.

THE CROSSLEY OIL ENGINE.

Governing

is effected by an automatic variation of the stroke of the oil pump. Impulses take place at each cycle, the strength of such impulses being controlled according to the load of the engine.

Vaporisation :

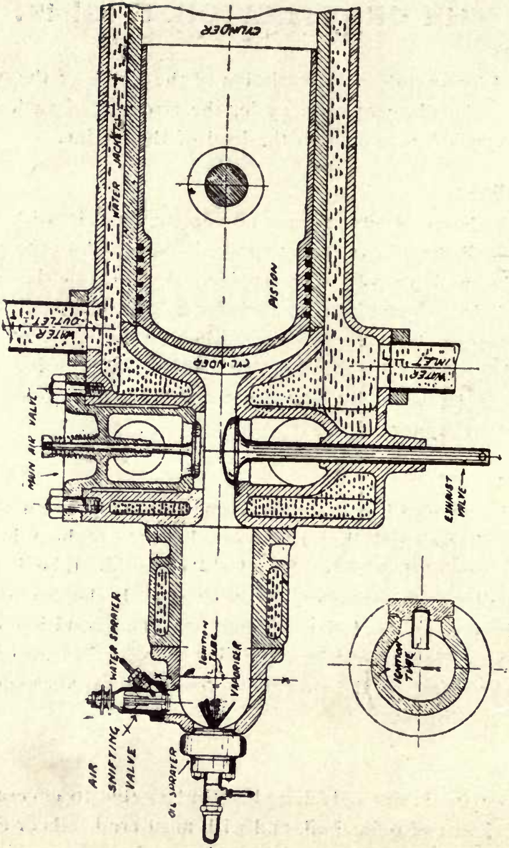
A rich charge of oil spray, or oil vapour, and air, with, if desirable, a small amount of water spray, is admitted to the vaporiser during the suction stroke of the engine. At the same time the main charge of air is drawn into the cylinder by a mechanically operated valve. During the compression stroke the air is forced into the richer charge, thereby diluting the vapour and causing the temperature to be raised by wall contact and by the work converted into heat by compression.

Ignition :

The increase of heat on every compression stroke automatically fires the charge, and thus no external source of heat is required after the engine has once started. An ignition tube is provided in the wall of the vaporiser to concentrate the heat at one point, and thus ensure regularity of ignition. The resulting explosion can be controlled at will by admitting more or less water, or none at all, according to the prevailing temperature consequent upon working conditions.

Fuel :

The engine is not only lampless, but is able to effectually deal with all classes of refined oil, and with most crude oils or distillates.



THE CROSSLEY OIL ENGINE (*see page* 93).

It is, therefore, claimed by the makers, that, although it may at first be intended to work with refined oil, it can be at any time operated with crude oil, if it be desirable for any reason.

THE "DAN" OIL ENGINE.

This is a vertical marine type, running at moderate speeds.

Governing

is effected by automatic reduction of the length of the pump stroke as the engine speed tends to increase. Variation of speed over a wide range can be obtained by a hand adjustment acting directly upon the governor and controlling the quantity of oil admitted, thus permitting any speed to be maintained for long periods.

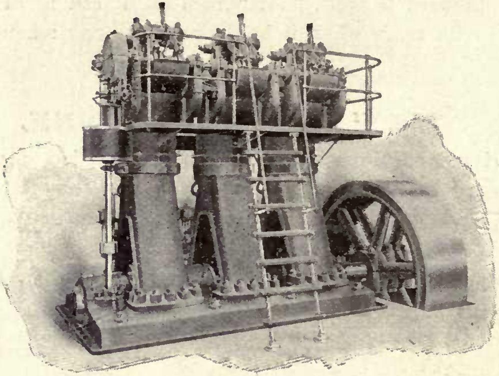
Vaporisation:

The oil is injected through a nozzle in the vaporiser impinging upon the walls and becoming instantly vaporised. The required heat is maintained by the continuous firing and the vaporiser cannot become overheated, which would cause the oil to crack and form deposit. Each injection of oil occurs during the exhaust stroke of a preceding cycle, so that the fresh charge is retained within the hot vaporiser for a long period. The makers have found this deviation from usual practice to increase both the power and economy of the engine. Air is admitted directly into the main cylinder by a separate valve.

Ignition

is due to the combined effects of dilution with air, contact with cylinder walls, and temperature due to compression. A lamp is only necessary when starting.

THE DIESEL OIL ENGINE.



This engine works upon the same general principle, or "Otto" cycle, as the others described in these pages, but has many points of difference. It is built in various sizes up to 1,200 b.h.-p.

The fuel is injected into a volume of highly compressed air (at about 500 lbs. pressure per square inch), having a temperature sufficient to cause the fuel to be burnt upon injection. Thus neither vaporiser nor ignition device is needed.

The oil is forced by a pump—the output of which is automatically adjusted by the governing mechanism—into a valve box, and is pulverised by passing through a number of perforated plates. The pressure, needed to inject this fuel into the highly heated air within the cylinder, is provided by a blast of air at a pressure of about 100 to 150 lbs. per square inch higher than the main air charge. The oil thus enters the cylinder through a nozzle of special

design, in the form of spray, and its gradual and complete combustion is continued until the supply is cut off in proportion to the load being carried. Under full load the injection of oil is continued for about one-tenth of the piston's stroke. A special feature of the engine is the very close governing obtained by this method of control; the fuel pump before each working stroke delivering the exact amount of fuel required for combustion, in accordance with the load at that stroke.

The engine is designed to use crude petroleum, costing about 2d. per gallon, and to ensure further economy by obtaining higher thermal efficiency than engines of the usual types can, at present, claim. The engine is more complicated, but is by no means beyond the intelligence of any skilled mechanic. It is more costly than others, but its low cost of fuel and high efficiency outweigh this disadvantage. To provide a means of comparison it may be restated here that Oil Engines of the usual design—of generally smaller sizes—have under tests given a mechanical efficiency of 80 to 85 per cent. and a thermal efficiency of 16 to 19·89 per cent. The Diesel Engines have been proved to give a mechanical efficiency of from 75 per cent. in 35 B.H.P. size to 80 per cent. in 160 B.H.P. size under full loads, the thermal efficiency ranging from 28·7 to 32·3 per cent. in similar sizes. The Diesel Engine, therefore, will be seen to give greater economy of fuel at the sacrifice of an increased amount of power absorbed by its own mechanism.

In addition to the usual parts common to all Oil Engines, the Diesel Engine requires a *starting device*, compressed air being stored during the run of the engine in suitable reservoirs (at about 800 lbs. per square inch), by means of the air pump. In the case of a new engine the makers send the reservoirs already charged. A lever

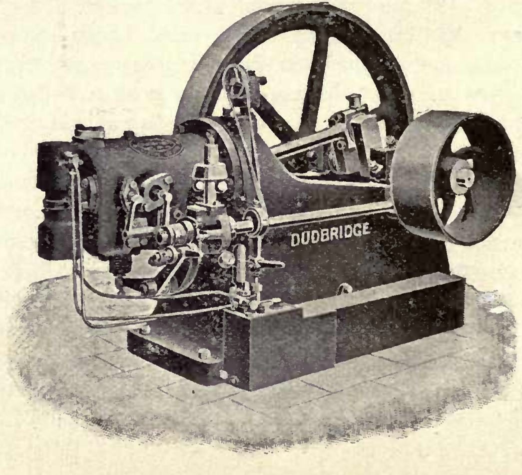
hand-barring gear is provided to set the engine-crank in the correct starting position. The oil gravitates from a reservoir through filters, and the *fuel pump* delivers it to the inlet valve box, the quantity of oil being varied to suit the engine's load by the operation of the governor.

The air blast for forcing the combustible into the cylinder against the terminal compression pressure is provided by a two-stage compressor, drawing the air direct from the atmosphere.

The *lubricating oil pump* forces lubrication into the cylinder to oil the piston, and also to the small end of the connecting rod within the piston.

DUDBRIDGE OIL ENGINE.

Made in 12 *sizes, from* 1 *to* 50 *B.H.P.*



Governing:

The Governor is of the centrifugal type, and its mechanism is designed so that at excessive speeds a connection is missed, which under normal conditions operates the spindle of the vapour valve and, simultaneously, the plunger of the pump. The explosions are, therefore, entirely cut-out when not required. The speed can be varied while engine is working.

Vaporisation:

Vaporisation is effected by the heat of a continuously burning lamp, which at the same time keeps the ignition tube red-hot. The oil is delivered through a measuring valve to an internal tube within the vaporiser and a small amount of air is drawn in through an outside cylinder, the heat from the lamp passing between the internal vapour tube (which is fitted with baffle plates to aid instant vaporisation) and the enclosing air cylinder. The supply of oil can be altered while engine is running by adjusting the measuring valve. The vapour and air are admitted at every opening of the vapour valve into the cylinder, into which a further supply of air is admitted through a separate valve. When the speed of the engine is excessive the vapour valve is kept to its seat, allowing air only to enter the cylinder, and at the same time the oil pump is thrown out of action, thus preventing overcharging of the cylinder.

Ignition:

Ignition is effected at the highest point of compression by means of a tube kept red-hot by a continuously burning lamp, which at the same time heats the vaporiser. This lamp is of the usual type and is fed by the pump which supplies the vaporiser. When desired, the patent magneto ignition gear can be fitted in place of the lamp and incandescent tube.

"FIELDING" OIL ENGINE.

Governing:

The speed of the engine is controlled on the "hit and miss" principle, connection between the operating mechanism and the vapour valve and oil pump being prevented when the normal rate of revolution is momentarily exceeded.

Vaporisation:

A charge of oil is injected, by a pump, through a spraying nozzle into the vaporiser, the latter being heated by a continuously burning lamp. A small amount of air is drawn into the vaporiser past an automatic valve whenever the vapour valve permits the suction of the engine piston to be communicated to the vaporiser. The main charge of air is admitted through a mechanically moved valve.

Ignition:

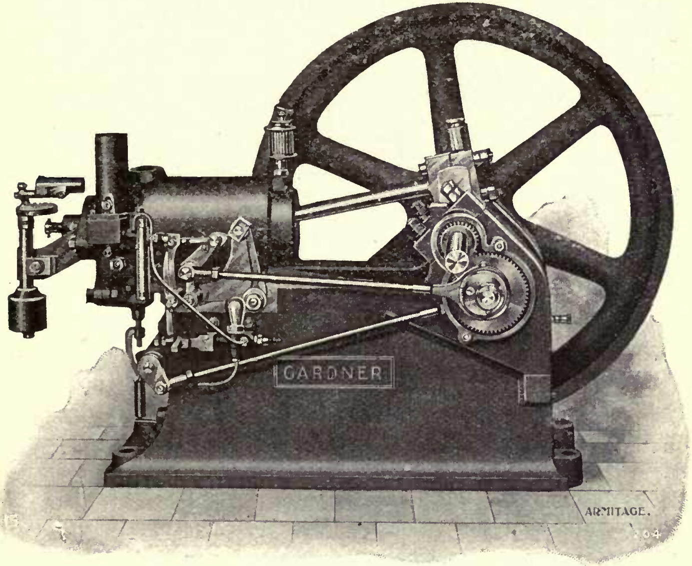
is by means of an incandescent tube. Water connection is provided so that when the engine has to work up to its maximum power as a working load the tendency to pre-ignition is obviated.

General:

Even on small power engines, on a "brake" test continued over eight hours, the total oil consumption has been proved to be rather under ·625 lb. per B.H.P. hour.

GARDNER OIL ENGINE.

Made in 16 sizes, from ½ to 45 B.H.P.



The oil reservoir is placed about a foot above the top of the cylinder, but supported against a convenient wall, not upon the engine itself.

The oil supply gravitates to the vaporiser inlet from the raised reservoir, passing through a small measuring pump. (See Fig. 1, page 26.)

Governing:

The Governor is of the inertia type and is driven, as is also the exhaust valve, by means of an eccentric. When the speed of the engine is excessive, the mechanism misses a connection with one end of a lever which operates both the oil pump and the vapour valve. By this means the vapour is not admitted to the cylinder, and no more oil is delivered to the vaporiser until the speed again slows down. The normal speed can be regulated while the engine is working.

Vaporisation:

Vaporisation is effected by means of a continuously burning lamp, which keeps the vaporiser at a sufficient heat to vaporise a constant quantity of oil, whatever the load on the engine. The oil is delivered to the vaporiser by gravity through a measuring pump, the stroke of which is adjustable; but when once set to suit the particular brand of oil used, this adjustment needs no alteration. The vapour formed is drawn into the cylinder with a small quantity of air whenever the vapour valve is opened by the governor, and there it mixes with the main charge of air drawn in by a separate valve, forming a combustible mixture. Whenever the speed of the engine exceeds the normal, the vapour valve is kept upon its seat and the main air valve then admits a non-explosive charge only. When the engine is working above half load a small stream of water is allowed to enter the cylinder with the main air charge to delay ignition.

Ignition:

Ignition takes place at the point of highest compression by means of a tube kept hot by the same lamp that simultaneously

heats the vaporiser. This lamp is worked by air pressure, and is similar in action to the lamps usually used, but differs slightly in details. At intervals of four to six hours during the day the air pressure necessary is maintained or renewed by a few strokes of a hand pump.

THE "GRIFFIN" OIL ENGINE.

This engine has several points which deserve special mention. All marine engines are made with two cylinders, or in multiples of two, the piston rods being attached to a crosshead from which a common connecting rod is coupled to the crank. Thus the latter receives an impulse at every revolution when the engine is working under full load. For stationary purposes the ordinary type of single-cylinder horizontal is made.

Governing

is effected by "hit and miss," so that better economy of the engine can be obtained on intermediate powers than is possible with engines designed to run on charges of varying richness.

Vaporisation

of the oil is a special feature. After preliminary heating up by means of a blowlamp to obtain the necessary temperature for starting, the oil is sprayed in a finely divided state into the vaporiser, where it becomes vaporised. Maintenance of working temperatures is obtained by utilisation of the waste heat of the exhaust gases, and under no circumstance is the vaporiser subjected to a temperature exceeding 400 degs. F. Thus the fuel is never decomposed or gasified, which would result in the "fixing" of a portion of the hydro-carbons contained in the oil, while the remainder would form

a tarry deposit. The makers claim that the vapour passing from the vaporiser, when passed through a still, condenses again into pure petroleum, the exact quantity vaporised being thus recovered.

It is thus possible to utilise almost any kind of liquid fuel, ranging from refined to crude oils, as the lighter portions only are taken into the cylinders as vapour, the heavier residue remaining in the vaporiser, from which it passes continuously by a pipe into any convenient receptacle.

Ignition

is by means of an externally heated tube, as constancy and regularity are thus ensured, the attendant being able to judge the temperature by observing the colour of the tube, and thus to make any slight adjustment that may be necessary.

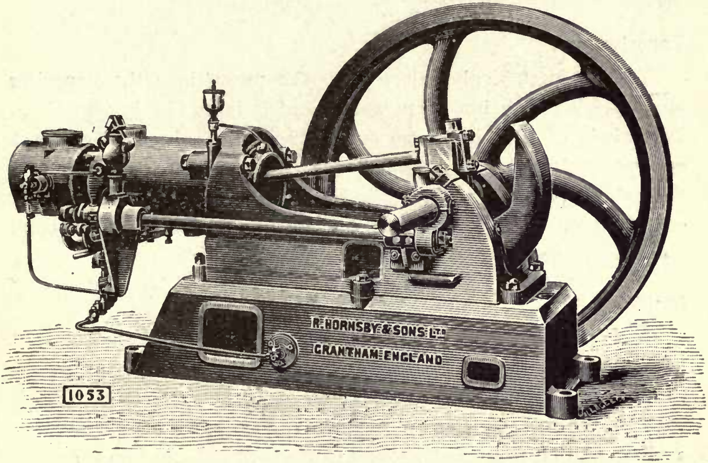
General:

Engines of 20 H.P. and upwards are fed with a mixture of water and oil, the water passing into the vaporiser with the oil, and not separately admitted into the cylinder. Smooth and economical running results.

The marine type of engines from 6 to 35 H.P. are fitted with a special form of starting mechanism, consisting of a winch, which is connected by an endless chain to a free flywheel. As soon as a rapid rotation has been given to the flywheel, a friction clutch is operated, which being keyed to the engine crankshaft, causes the momentum of the flywheel to drive the engine mechanism. Thus two or more complete cycles are provided for, and the normal operations of the gear being effected by such means, the engine takes up its duties. Larger engines, from 40 H.P. and upwards, are fitted with an auxiliary starting engine.

HORNSBY OIL ENGINE.

Made in 24 sizes, from 1½ to 125 B.H.P. and upwards.



The oil reservoir is placed on the ground in or near the base of the engine. The supply of oil to the vaporiser is delivered by a pump worked by the air-valve lever.

Governing:

The speed of the engine is controlled by a centrifugal governor designed to give motion to one end of a lever which, at its other end, depresses a valve in the vaporiser valve box, causing some of the oil thrown by the pump to escape through an overflow pipe

back to the oil reservoir, thus graduating the explosive effect of the charges in proportion to the duty being performed by the engine. This method is necessary, as the vaporiser depends for its efficiency upon continuous explosions.

Vaporisation:

The oil is suddenly injected by the pump into the vaporiser already filled with hot spent gases, and is immediately vaporised. The whole of the air charge enters the main cylinder through a separate valve (passing through the same passage that conducts the exhaust gases from the cylinder it is thereby warmed upon its entrance) and fills the space created by the outstroke of the piston. (See Fig. 8, page 39.)

Ignition:

Ignition is effected by the warmed air being compressed to a high degree by the return stroke of the piston and causing a sufficient quantity to pass through the contracted neck into the vaporising chamber, to mix with the oil vapour there. The mixture, at first too rich to ignite, becomes explosive by the incoming supply of air. At the end of the compressing stroke, the proper explosive proportion of air is attained simultaneously with the greatest heat due to compression, and this with the heat of the vaporiser walls causes ignition of the whole charge, with instant explosion and expansion, thus giving the "power" stroke.

THE "KROMHOUT" OIL ENGINE.

This engine is specially designed for marine work, being of vertical four-cycle type.

Governing

is effected by causing the "inertia" of the governing mechanism to engage a slide piece placed between the operating lever and the exhaust valve spindle, thereby preventing the exhaust valve from being lifted whenever the speed of the engine is above the normal. At the same time the mechanism operating the fuel pump is also disconnected, so that no fresh charge is admitted. Thus the engine is controlled by the "hit and miss" principle.

Vaporisation :

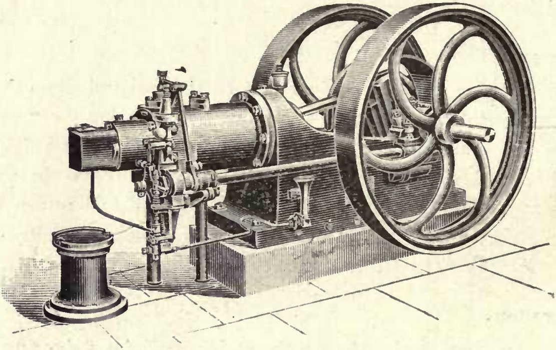
The vaporiser is placed directly under the inlet valve in such a position that it can be easily removed for cleaning. A small quantity of petrol or motor spirit is used when starting, sufficient absorption of heat being thus established to allow the engine to work with paraffin, the change from one fuel to the other being automatic. The oil is forced into the vaporiser by a small plunger pump driven by an eccentric on the cam shaft.

Ignition

is by low-tension oscillating magneto, with make-and-break sparking plug, driven from the same shaft as the exhaust valve.

NATIONAL OIL ENGINE.

Made in 8 sizes, from 2 to 26 B.H.P.



Governing :

The governor regulates the quantity of oil admitted to the vaporiser at each cycle, and this it does by varying the length of the pump's stroke according as the speed of the engine varies. Centrifugal governors are fitted for all sizes.

Vaporisation :

The vaporiser is formed by a continuation of the combustion space behind the piston projecting beyond the main casting. A metal hood is arranged to prevent radiation of heat from the vaporiser in the usual way. There is no valve between the oil inlet nozzle and the cylinder of the engine. The oil is injected by

a pump into the vaporiser, when it is immediately vaporised, following the outward movement of the piston upon its charging stroke. At the same time as the oil is injected a mechanically moved air valve allows pure air to be drawn in immediately behind the piston, the space behind which at the completion of the charging stroke is filled with the oil vapour and air in an unmixed state, and therefore incombustible condition.

Ignition:

As the piston returns into the cylinder the air is forced back into the oil vapour, and both air and vapour into the combustion chamber under the force of compression. The temperature of the mixture, of course, rises; but inasmuch as the intimate mixing necessary for combustion has not yet been attained, a high degree of compression can be thus reached without liability to pre-ignition.

The piston is of special shape and the back end of same is made to fit the reduced diameter of the combustion chamber. Thus the remaining mixture entrapped by the piston is forced by the continued movement along a specially arranged bye-pass to the ignition tube end of the vaporiser, meeting there the richest portion of the oil vapour, and causing instant ignition and combustion of the whole charge. The following outward movement of the piston on the power stroke causes a suction effect through the bye-pass passage, and the hot gases are thereby drawn past the ignition tube into the main portion of the cylinder. This arrangement keeps the tube heated to the effective degree and renders the use of a continuously burning lamp unnecessary. The method adopted is claimed to time the ignition of the mixture, whatever the load, and ensures that the oil is used in the most economical way.

PETTER OIL ENGINE.

Made in 10 *sizes, from* $1\frac{1}{2}$ *to* 45 *B.H.P.*

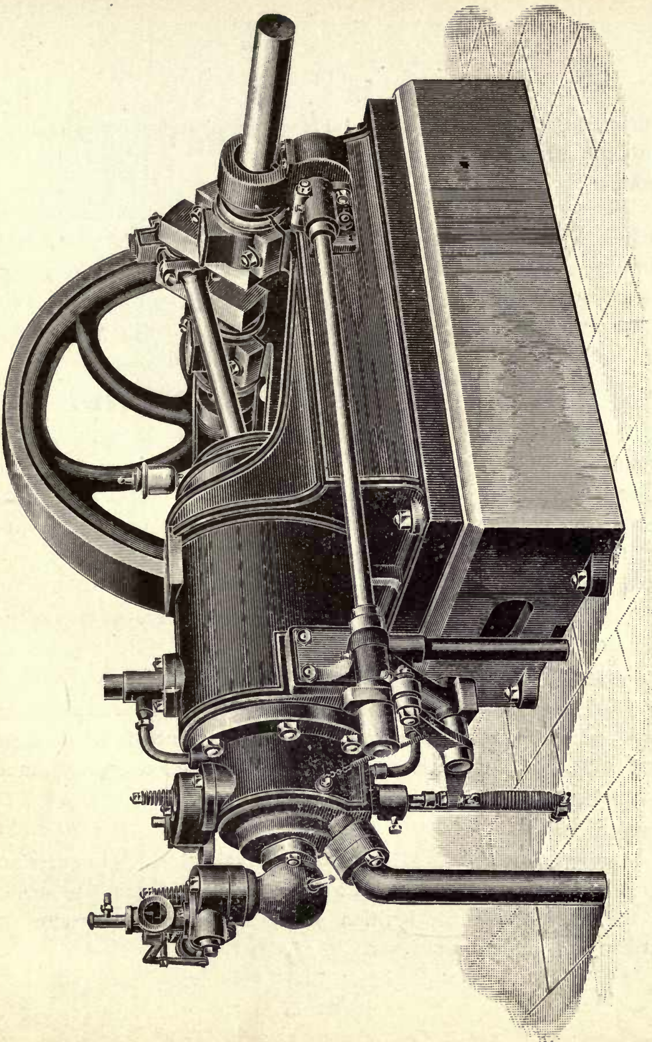
The oil reservoir in the smaller size is placed above the engine cylinder and the oil supply is delivered to the vaporiser by gravity. In the larger sizes the oil is pumped from the reservoir on the ground level. The oil passes through an oil valve, which regulates the quantity admitted as determined by the governing apparatus. (See Fig. 2, page 20.)

Governing:

The governor is of the centrifugal type and actuates a lever connected to a curtain or sleeve for reducing the area of the air inlet by means of a short rod, which also bears against the stalk of the oil supply valve when working, supporting the latter more or less from its seat in proportion to the movement of the governor lever, and thus regulating the amount of oil and air admitted to the vaporiser at each opening of the automatic suction inlet valve. By this means the engine fires a charge every cycle, thus keeping the heat of vaporiser and ignition tube to a practically constant temperature.

Vaporisation:

The vaporiser under working conditions is kept hot by an uninterrupted series of explosions, but at starting is heated by a lamp in the ordinary way. The oil and air are drawn in through a valve, which is opened automatically by the suction of the piston on its charging stroke. The quantity of oil supplied is regulated by the governor, which also varies the opening for the air so that both oil and air are always in correct proportion under all loads.



During the admission stroke the oil is vaporised and mixes intimately with the air.

Ignition :

The combustible mixture of oil vapour and air is exploded at each cycle, no "cutting out" occurring. The resultant heat keeps the vaporiser sufficiently hot to ensure proper and complete vaporisation and also to maintain an internal alloy ignition tube at a temperature to cause ignition at the highest point of compression.

THE "RATIONAL" OIL ENGINE.

These engines are made in two types—one to be heated when starting from a lamp, which is afterwards extinguished; and the other being started with petrol, which generates sufficient heat to enable the operation, after a few minutes, to be continued with paraffin.

Governing

is by throttling a constant and proportionate mixture of oil vapour and air.

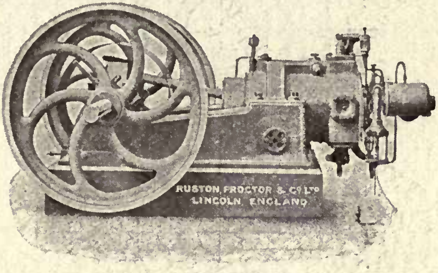
Vaporisation :

The oil is fed by gravity into the vaporiser, which is kept at the effective temperature by means of the waste heat of the exhaust gases. The inlet valve is automatic, and the full charge of air is drawn through the vaporiser.

Ignition

in one type is by means of an automatic igniter, which requires no flame or auxiliary source of heat when once the engine is started. In the second type the ignition is by high-tension magneto or battery and induction coil.

THE "RUSTON" OIL ENGINE.



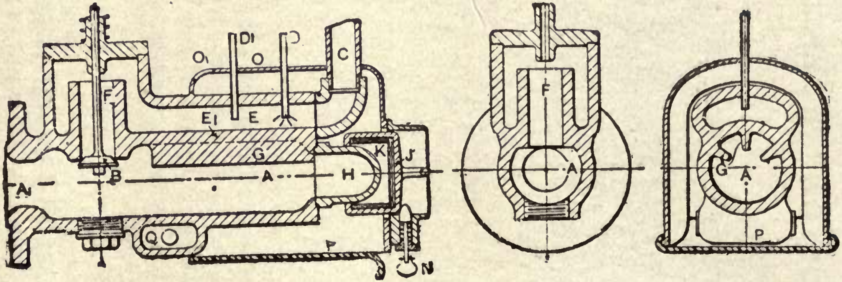
These are made in sizes ranging from 2½ to 85 B.H.P. for stationary purposes, and from 2½ to 23 B.H.P. as portable engines. From 5 B.H.P. upwards they are suitable for running on any brand of refined or crude oil of good quality by merely adjusting the oil pump.

Governing

is on the "hit and miss" system. On all sizes below 10 B.H.P. an "inertia" mechanism is used, while all sizes above are fitted with a "centrifugal" governor. Upon excess of speed the mechanism prevents both the vapour valve and oil pump being operated until the normal speed is regained consequent upon the missed explosion.

Vaporisation

is effected by injecting the liquid fuel by a simple pump into the vaporiser through the spray D in the accompanying figure, and



THE "RUSTON" OIL ENGINE (*see page* 113).

passing it, with a limited amount of air entering through the pipe C, over the hot metal surface (ribbed internally, as shown at G). The vaporised air then enters the cylinder A through the vapour valve B, a further supply of air being introduced through a separate valve.

After the preliminary heating by means of a blow-lamp the heat required for vaporisation is maintained by that produced in the metal by absorption from the working charges.

Ignition

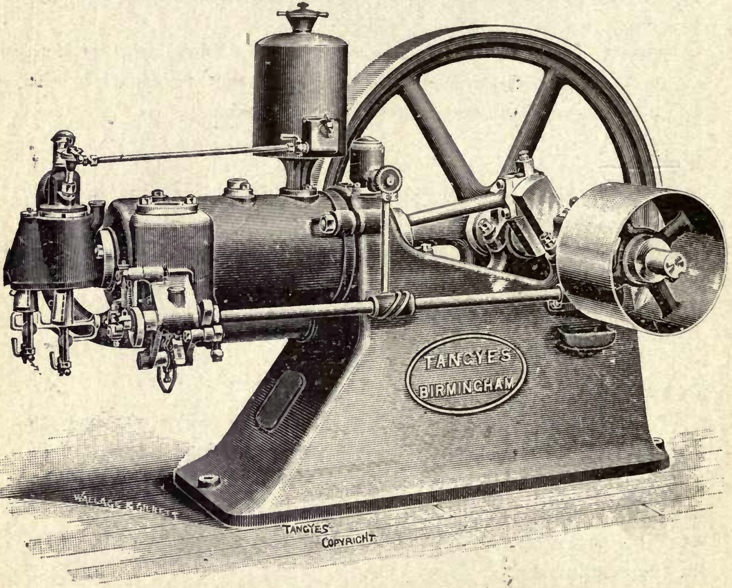
is by means of an igniting bulb, shown at H, in the figure, enclosed in a cover K, which is withdrawn during the preliminary heating and thus exposed to the lamp flame. The bulb is afterwards kept sufficiently hot by the successive explosions to maintain regular firing. Adjustment of the main air supply and the injection of water permit the ignition being controlled when required.

General:

A certificate of test is furnished with every engine, showing the results obtained during a 2 hours' run at " test " load, which usually is about 5 per cent. under the maximum possible output. The Effective (brake) H.P. and fuel consumption is recorded, as well as the time occupied in starting from cold and the amount of oil burnt in the starting lamp.

TANGYE OIL ENGINE.

Made in 10 *sizes, from* 2 *to* 30 *B.H.P.*



The oil reservoir is supported on the top of the engine cylinder. The oil supply flows by gravity to the vaporiser, and its velocity or rate of flow is kept constant by means of the supply being drawn from a small box by the side of the main reservoir, the latter being completely airtight until the engine reduces the level of oil in the

side box, when a small hole being thereby uncovered, allows admission of air to the large tank, and the consequent flowing of oil from the reservoir to the small box until the hole is again covered and air excluded. (See Fig. 3, page 28.)

Governing :

A "hit and miss" governor of the inertia type is used, and when the speed of the engine is above the normal, the exhaust valve is propped open by a catch which automatically comes into play whenever the governor lever fails to press against the small lever or finger with which the catch is connected. The open exhaust port allows the hot spent gases to return and follow the piston during the succeeding out-stroke, and thereby not only prevents the entry of a fresh charge, but the cylinder walls are not cooled as they would be if pure air only were drawn in during the idle stroke ; neither is there any compression resistance to retard the motion of the engine during idle strokes, All these points make for economy. The speed of the engine can be varied whilst running.

Vaporisation :

The vaporiser is kept hot by means of a lamp continuously burning. The oil is delivered by gravity to the conical face of the air valve seating. The air valve is held to its seat by a spring, the tension of which is overcome by the suction of the piston upon the charging stroke. The oil and air are admitted by the inlet valve into the vaporiser (which is in direct communication with the cylinder) and follows the piston's out-stroke. The vaporiser is kept sufficiently hot to vaporise the oil during its admission with the full charge of air. The supply of oil is adjusted to suit the load

being carried by the engine. The supply of air is not adjustable when running. (See Fig. 6, page 30.)

Ignition:

Ignition takes place by a tube kept red-hot by a wickless blow lamp of the usual type supplied with the necessary pressure to ensure a hot and steady flame by means of an elevated supply tank placed 7 to 10 ft. above the ground level. In the smallest size of engine one lamp coil under the ignition tube is sufficient to supply all the heat necessary for both tube and vaporiser, but in the larger engines one or two coils are sometimes used under the vaporiser in addition to that under the tube. The small copper pipe connecting the lamp with its supply tank is coiled under the cylinder so as to allow the lamps to be moved when necessary without breaking of joints. Water injection is provided to control ignition when heavy loads are being carried.

THE THORNYCROFT OIL ENGINE.

These are specially designed for automobile and marine work, and are fitted with a "change-over" device, so that the engine may be fed with either petrol or paraffin. By preliminary heating with a blow-lamp, paraffin only may be used.

Governing

is by throttling the mixture admitted to the working cylinders. This is only fitted when specified.

Vaporisation

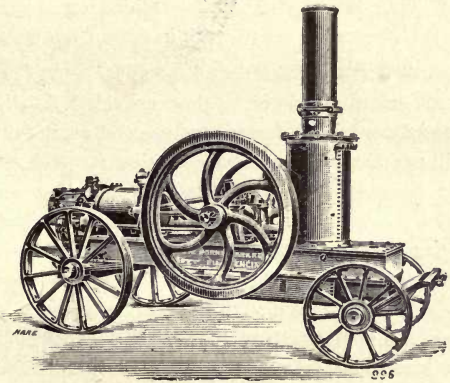
is effected by causing the oil to be vaporised within a carburettor heated by continuous explosions, the exhaust being by-passed for

this purpose. A portion of the air charge is sucked by the engine past the float-box jet, picking up the fuel and taking it into the U-tube vaporiser, which is surrounded by an exhaust jacket. Upon leaving the vaporiser additional air is admitted by a hand or operated sleeve, diluting the rich mixture to a proper explosive strength, thence through the throttle valve to the cylinder.

Ignition

is by make-and-break electric spark generated from a low-tension magneto or by jump spark from high-tension magneto, as may be desired. Provision is made for timing by the usual distributor.

Many combinations of various size are made to suit varying conditions. The smaller engines run at about 1,000 revolutions per minute, and the largest—developing 150 B.H.P. on paraffin with four cylinders—run at 600 revolutions per minute.



PORTABLE OIL ENGINE (*see page* 120).

PORTABLE OIL ENGINES.

The advantages of Oil Engines over other motors have been dealt with in the first portion of this handbook, but no mention has hitherto been made of the great convenience of "Portable" Oil Engines for agricultural purposes.

To realise the great value appertaining to their use in this direction it is sufficient to enumerate the following points:—

(*a*) They avoid the necessity of auxiliary vehicles for carrying coal and water.

(*b*) They ensure immunity from fires, owing to the entire absence of sparks.

(*c*) They can be designed to carry sufficient fuel and water to suffice for a long day without replenishment.

(*d*) They need no continual stoking or attention.

(*e*) They can be set to work in fifteen minutes and stopped instantly.

The mechanism is similar to that provided for the stationary engines described in the foregoing pages, but it will be noticed from the illustration that the base casting is much shortened and the weight brought down close to the axles to prevent "top-heaviness."

The engine is bolted to a platform provided with four wheels, the front pair being arranged upon a swivelling forecarriage. A slipper and chain is usually provided for use when descending hills, and the equipment is completed by substantial "chocks," for scotching the wheels, iron bars being used to form a rigid double connection between front and back axles on each side, the idea being to con-

vert the wheels into temporary, but effectual standards. The fore-carriage is provided with shafts, or pole, according to the weight and size of engine.

The crank should be semi-enclosed with an oil splash guard, and, in order to keep off chaff and dust, the open end of the cylinder should be fitted with a removable cover to protect the piston at each out-stroke.

The platform should support exhaust and air silencers ; reservoirs for both oil and water, of sufficient capacity for a day's work ; pressure pump for lamps ; and water pump for circulating the water round the engine cylinder jacket from and to the water tank.

It is to the water-circulating arrangements that a purchaser should look after deciding upon the design of engine he most favours. Unless these are effective the engine will require a fresh supply of cold water every few hours. For long hours and for warm climates an overhead "canopy" is to be preferred. In this arrangement the water is sucked by a pump from the reservoir, forced round the cylinder jacket and up to a pipe running horizontally over the engine, from back to front, at right angles to the axles. This horizontal pipe is drilled with numerous small holes, which cause the water to be divided into small streams, which, running down the sides of the canopy, are exposed to the cooling effect of the air. The water, collected in troughs, is then conducted, by a suitable pipe, back to the water tank. Ordinarily, however, a cheaper arrangement is applied, the cooling being effected—in a less degree—by causing the heated water to flow through holes in a board or tray, placed within a cylinder, through which a current of air is always being induced, by the emission of the hot exhaust gases into a short funnel above the cylindrical casing. Any losses

from evaporation or leakages should be made good when required, as it is important for good results that a sufficiency of water should always be at hand. The pumps are usually of the ram type, and are driven from the camshaft, but occasionally the valveless centrifugal pumps are used for the purpose.

Another point to examine is the range of angular "leads" for belts: in some design due importance has not been given to this matter, and the relative positions of the engine and driven machine require careful adjustment to allow a clear drive.

The fuel consumption of Portable Oil Engines is not quite so low as in the stationary types, owing to the circulating pump detracting from its mechanical efficiency, but this matter is not usually of prime importance, convenience in moving about, lightness, steadiness of running, reliability without undue attention, and efficient water circulation being considered of relatively greater value.

Self-propelled Oil Engines or "Tractors" are now common. In countries where water is scarce and coal expensive there is a great field for such engines.

At the Derby Show of the Royal Agricultural Society of England in June, 1906, both Messrs. J. B. Petter and Sons, Ltd., and Samuelson and Co. exhibited Oil Tractors of moderate power for farmers' use, of considerable interest. Messrs. R. Hornsby & Sons have secured an award from the British War Office for a Military Tractor, and make a special type of Self-propelling Tractor for negotiating difficult country-

HAMPTON & CO., Printers, 12 & 13, Cursitor Street, London, E.C.